

Natural Communities of Michigan: Classification and Description



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Cover photos: Top left, Dry Sand Prairie at Indian Lake, Newaygo County (M. Kost); top right, Limestone Bedrock Lakeshore, Summer Island, Delta County (J. Cohen); lower left, Muskeg, Luce County (J. Cohen); and lower right, Mesic Northern Forest as a matrix natural community, Porcupine Mountains Wilderness State Park, Ontonagon County (M. Kost).

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Table of Contents

Acknowledgements	ii
Introduction	1
Natural Community Global and State Ranks	2
Global and State Element Ranking Criteria	3
Natural Communities by Ecological Groups.....	4
Key to the Natural Communities of Michigan	5
Soil pH Ranges.....	16
Community Descriptions.....	17
PALUSTRINE COMMUNITIES	18
MARSH COMMUNITIES.....	18
Submergent Marsh	18
Emergent Marsh	21
Great Lakes Marsh	25
Northern Wet Meadow.....	29
Southern Wet Meadow.....	33
Inland Salt Marsh	37
Intermittent Wetland.....	39
Coastal Plain Marsh.....	43
Interdunal Wetland.....	47
WET PRAIRIE COMMUNITIES.....	51
Wet Prairie.....	51
Wet-mesic Prairie.....	54
Wet-mesic Sand Prairie.....	57
Lakeplain Wet Prairie.....	61
Lakeplain Wet-mesic Prairie.....	65
FEN COMMUNITIES	69
Prairie Fen	69
Northern Fen	75
Coastal Fen.....	81
Patterned Fen.....	85
Poor Fen	89
BOG COMMUNITIES	94
Bog	94
Muskeg.....	99
SHRUB WETLAND COMMUNITIES.....	105
Northern Shrub Thicket.....	105
Southern Shrub-Carr.....	109
Inundated Shrub Swamp	112
FORESTED WETLAND COMMUNITIES	115
Poor Conifer Swamp	115
Rich Conifer Swamp	121
Rich Tamarack Swamp	126
Hardwood-Conifer Swamp.....	130
Northern Hardwood Swamp.....	135
Southern Hardwood Swamp.....	140
Floodplain Forest.....	145
Wet-mesic Flatwoods.....	153
PALUSTRINE/TERRESTRIAL COMMUNITIES.....	157
Wooded Dune and Swale Complex.....	157
TERRESTRIAL COMMUNITIES	161
PRAIRIE COMMUNITIES	161

Dry Sand Prairie	161
Dry-mesic Prairie	166
Mesic Sand Prairie.....	170
Mesic Prairie	173
Hillside Prairie.....	177
SAVANNA COMMUNITIES	181
Pine Barrens	181
Oak-Pine Barrens	185
Oak Barrens.....	190
Oak Openings.....	196
Bur Oak Plains.....	201
Lakeplain Oak Openings	205
FOREST COMMUNITIES	209
Dry Northern Forest	209
Dry-mesic Northern Forest.....	212
Mesic Northern Forest.....	215
Dry Southern Forest	220
Dry-mesic Southern Forest.....	223
Mesic Southern Forest.....	226
Boreal Forest	231
PRIMARY COMMUNITIES.....	236
Sand and Gravel Beach	236
Open Dunes	239
Great Lakes Barrens	244
Alvar.....	247
BEDROCK GLADE COMMUNITIES	251
Limestone Bedrock Glade	251
Granite Bedrock Glade.....	256
Volcanic Bedrock Glade	259
Northern Bald.....	262
COBBLE SHORE COMMUNITIES	265
Limestone Cobble Shore	265
Sandstone Cobble Shore.....	268
Volcanic Cobble Shore.....	271
BEDROCK LAKESHORE COMMUNITIES	274
Limestone Bedrock Lakeshore	274
Sandstone Bedrock Lakeshore	278
Granite Bedrock Lakeshore.....	281
Volcanic Bedrock Lakeshore	284
LAKESHORE CLIFF COMMUNITIES	288
Limestone Lakeshore Cliff.....	288
Sandstone Lakeshore Cliff	292
Granite Lakeshore Cliff.....	295
Volcanic Lakeshore Cliff	298
INLAND CLIFF COMMUNITIES.....	301
Limestone Cliff.....	301
Sandstone Cliff.....	305
Granite Cliff	308
Volcanic Cliff.....	311
SUBTERRANEAN/SINK COMMUNITIES	314
Cave.....	314
Sinkhole.....	316

Introduction

This natural community classification is designed to serve as a tool for those seeking to understand, describe, and document the diversity of natural communities in Michigan. A natural community is defined as an assemblage of interacting plants, animals, and other organisms that repeatedly occurs under similar environmental conditions across the landscape and is predominantly structured by natural processes rather than modern anthropogenic disturbances. While habitats such as agricultural fields, old fields, tree plantations, and so forth are significant components of Michigan's landscape, they are not described in this document. Natural communities were classified based on a combination of data from state-wide and regional surveys, intensive sampling and data analysis, literature review, and expert assessment. Within this document are lists of the 76 recognized natural communities (arranged both ecologically and alphabetically with associated global and state ranks), a dichotomous key to help users identify community types, and detailed descriptions of each natural community. The community descriptions provide information on landscape context, soils, natural processes, vegetation, rare species, biodiversity management considerations, and relevant literature. The information contained in this document is also available through the Michigan Natural Features Inventory (MNFI) Web site, where it is accompanied by photographs of the natural communities and links to related information. It is expected that the community descriptions will be updated as new information becomes available. Similarly, the structure of the classification may be modified should additional community types be recognized in the future.

The landscape of Michigan is extremely varied and as such, identifying natural communities is not always a simple task. The line between two community types can be quite clear where vegetation changes abruptly. However, where gradual changes occur in climate, soils, hydrology, and other factors, natural communities can subtly grade into one another, making it difficult to determine where to draw the line between community types. It is our hope that the accompanying key and community descriptions will allow users to more easily and confidently identify Michigan's natural communities.

This classification is meant to guide the identification of natural habitats that represent the range of native ecosystems known to occur in Michigan, both historically and today. Protecting and managing representative natural communities is critical to biodiversity conservation, since native organisms are best adapted to environmental and biotic forces with which they have survived and evolved over the millennia. Michigan Natural Features Inventory maintains a database of occurrences of exemplary natural communities, rare plants, and rare animals found in Michigan. These occurrences provide critical information for assessing the conservation status of each natural community and rare species. The natural community classification and database make it possible for exemplary occurrences of each community to be identified, documented, and described. Together, the classification and associated database of exemplary natural community occurrences serve as a powerful tool for setting conservation goals aimed at protecting, monitoring, and managing a network of lands that represent the broad range of native ecosystems known to occur in Michigan. This "coarse filter" approach provides a strategy for identifying the critical lands necessary for conserving the diversity of native plants and animals that represent Michigan's natural heritage.

Natural Community Global and State Ranks

Community Name	State Rank	Global Rank	Community Name	State Rank	Global Rank
Alvar	S1	G2?	Mesic Southern Forest	S3	G2G3
Bog	S4	G3G5	Muskeg	S3	G4G5
Boreal Forest	S3	GU	Northern Bald	S1	GU
Bur Oak Plains	SX	G1	Northern Fen	S3	G3
Cave	S1	G4?	Northern Hardwood Swamp	S3?	G4
Coastal Fen	S2	G1G2	Northern Shrub Thicket	S5	G4
Coastal Plain Marsh	S2	G2	Northern Wet Meadow	S4	G4G5
Dry Northern Forest	S3	G3?	Oak Barrens	S1	G2?
Dry Sand Prairie	S2	G3	Oak Openings	S1	G1
Dry Southern Forest	S3	G4	Oak-Pine Barrens	S2	G3
Dry-mesic Northern Forest	S3	G4	Open Dunes	S3	G3
Dry-mesic Prairie	S1	G3	Patterned Fen	S2	GU
Dry-mesic Southern Forest	S3	G4	Pine Barrens	S2	G3
Emergent Marsh	S4	GU	Poor Conifer Swamp	S4	G4
Floodplain Forest	S3	G3?	Poor Fen	S3	G3
Granite Bedrock Glade	S2	G3G5	Prairie Fen	S3	G3
Granite Bedrock Lakeshore	S2	G4G5	Rich Conifer Swamp	S3	G4
Granite Cliff	S2	G4G5	Rich Tamarack Swamp	S3	G4
Granite Lakeshore Cliff	S1	GU	Sand and Gravel Beach	S3	G3?
Great Lakes Barrens	S2	G3	Sandstone Bedrock Lakeshore	S2	G4G5
Great Lakes Marsh	S3	G2	Sandstone Cliff	S2	G4G5
Hardwood-Conifer Swamp	S3	G4	Sandstone Cobble Shore	S2	G2G3
Hillside Prairie	S1	G3	Sandstone Lakeshore Cliff	S2	G3
Inland Salt Marsh	S1	G1	Sinkhole	S2	G3G5
Interdunal Wetland	S2	G2?	Southern Hardwood Swamp	S3	G3
Intermittent Wetland	S3	G2	Southern Shrub-Carr	S5	GU
Inundated Shrub Swamp	S3	G4	Southern Wet Meadow	S3	G4?
Lakeplain Oak Openings	S1	G2?	Submergent Marsh	S4	GU
Lakeplain Wet Prairie	S1	G2	Volcanic Bedrock Glade	S2	GU
Lakeplain Wet-mesic Prairie	S1	G1?	Volcanic Bedrock Lakeshore	S3	G4G5
Limestone Bedrock Glade	S2	G2G4	Volcanic Cliff	S2	G4G5
Limestone Bedrock Lakeshore	S2	G3	Volcanic Cobble Shore	S3	G4G5
Limestone Cliff	S2	G4G5	Volcanic Lakeshore Cliff	S1	GU
Limestone Cobble Shore	S3	G2G3	Wet Prairie	S2	G3
Limestone Lakeshore Cliff	S2	G4G5	Wet-mesic Flatwoods	S2	G2G3
Mesic Northern Forest	S3	G4	Wet-mesic Prairie	S2	G2
Mesic Prairie	S1	G2	Wet-mesic Sand Prairie	S2	G2G3
Mesic Sand Prairie	S1	G2	Wooded Dune and Swale Complex	S3	G3

Global and State Element Ranking Criteria

GLOBAL RANKS

- G1** = critically imperiled: at very high risk of extinction due to extreme rarity (often 5 or fewer occurrences), very steep declines, or other factors.
- G2** = imperiled: at high risk of extinction due to very restricted range, very few occurrences (often 20 or fewer), steep declines, or other factors.
- G3** = vulnerable: at moderate risk of extinction due to a restricted range, relatively few occurrences (often 80 or fewer), recent and widespread declines, or other factors.
- G4** = apparently secure: uncommon but not rare; some cause for long-term concern due to declines or other factors.
- G5** = secure: common; widespread.
- GU** = currently unrankable due to lack of information or due to substantially conflicting information about status or trends.
- GX** = eliminated: eliminated throughout its range, with no restoration potential due to extinction of dominant or characteristic species.
- G?** = incomplete data.

STATE RANKS

- S1** = critically imperiled in the state because of extreme rarity (often 5 or fewer occurrences) or because of some factor(s) such as very steep declines making it especially vulnerable to extirpation from the state.
- S2** = imperiled in the state because of rarity due to very restricted range, very few occurrences (often 20 or fewer), steep declines, or other factors making it very vulnerable to extirpation from the state.
- S3** = vulnerable in the state due to a restricted range, relatively few occurrences (often 80 or fewer), recent and widespread declines, or other factors making it vulnerable to extirpation.
- S4** = uncommon but not rare; some cause for long-term concern due to declines or other factors.
- S5** = common and widespread in the state.
- SX** = community is presumed to be extirpated from the state. Not located despite intensive searches of historical sites and other appropriate habitat, and virtually no likelihood that it will be rediscovered.
- S?** = incomplete data.

Natural Communities by Ecological Groups

(Names in bold are not tracked as natural communities)

PALUSTRINE

Marsh

Submergent Marsh
Emergent Marsh
Great Lakes Marsh
Northern Wet Meadow
Southern Wet Meadow
Inland Salt Marsh
Intermittent Wetland
Coastal Plain Marsh
Interdunal Wetland

Prairie

Wet Prairie
Wet-mesic Prairie
Wet-mesic Sand Prairie
Lakeplain Wet Prairie
Lakeplain Wet-mesic Prairie

Fen

Prairie Fen
Northern Fen
Coastal Fen
Patterned Fen
Poor Fen

Bog

Bog
Muskeg

Shrub

Northern Shrub Thicket
Southern Shrub-Carr
Inundated Shrub Swamp

Forest

Poor Conifer Swamp
Rich Conifer Swamp
Rich Tamarack Swamp
Hardwood-Conifer Swamp
Northern Hardwood Swamp
Southern Hardwood Swamp
Floodplain Forest
Wet-mesic Flatwoods

PALUSTRINE/ TERRESTRIAL

Wooded Dune and Swale Complex

TERRESTRIAL

Prairie

Dry Sand Prairie
Dry-mesic Prairie
Mesic Sand Prairie
Mesic Prairie
Hillside Prairie

Savanna

Pine Barrens
Oak-Pine Barrens
Oak Barrens
Oak Openings
Bur Oak Plains
Lakeplain Oak Openings

Forest

Dry Northern Forest
Dry-mesic Northern Forest
Mesic Northern Forest
Dry Southern Forest
Dry-mesic Southern Forest
Mesic Southern Forest
Boreal Forest

Primary

Sand and Gravel Beach
Open Dunes
Great Lakes Barrens
Alvar

Bedrock Glade

Limestone Bedrock Glade
Granite Bedrock Glade
Volcanic Bedrock Glade
Northern Bald

Cobble Shore

Limestone Cobble Shore
Sandstone Cobble Shore
Volcanic Cobble Shore

Bedrock Lakeshore

Limestone Bedrock
Lakeshore
Sandstone Bedrock Lakeshore
Granite Bedrock Lakeshore
Volcanic Bedrock Lakeshore

Lakeshore Cliff

Limestone Lakeshore Cliff
Sandstone Lakeshore Cliff
Granite Lakeshore Cliff
Volcanic Lakeshore Cliff

Inland Cliff

Limestone Cliff
Sandstone Cliff
Granite Cliff
Volcanic Cliff

SUBTERRANEAN/SINK

Cave
Sinkhole

Key to the Natural Communities of Michigan

- 1A. Subterranean or sink feature located in areas of karst topography primarily along the Niagaran Escarpment in the eastern Upper Peninsula and northeastern Lower Peninsula.
 - 2A. Occurring as cavities beneath the earth's surface, often with an opening to the surface, characterized by little or no light, no primary producers, and biotic communities of one or two trophic levels that import energy from outside the system **Cave**
 - 2B. Occurring as large depressions caused by the dissolution and collapse of subsurface limestone, dolomite, or gypsum. Bottoms of depressions sometimes filled with water. Exposed limestone vertical walls and large boulders sometimes present. Vegetative composition and structure generally reflect that of surrounding landscape **Sinkhole**
- 1B. Terrestrial (upland) or palustrine (wetland) community or a relatively equal mixture of both.
 - 3A. Wetland soils and vegetation prevalent. Uplands absent or limited in extent to occasional islands, peninsulas, or dune ridges interspersed among swales (i.e., Wooded Dune and Swale Complex, 19A, p. 7) **Wetland Communities, 45A, p. 10**
 - 3B. Upland soils and vegetation prevalent. Wetlands absent or limited in extent to occasional vernal pools or occurring within a repeated pattern of swales between upland dune ridges (i.e., Wooded Dune and Swale Complex, 19A, p. 7) **Upland Communities, 4A**
 - 4A. Little soil development, with exposed bedrock, cobble, or dune sands common **Primary Communities: Bedrock, Cliff, Dune, and Shore Communities, 23A, p. 8**
 - 4B. Evidence of mineral soil development. Exposed bedrock, cobble, or dune sand either absent or very minimally exposed at surface.
 - 5A. Mature trees present at densities greater than one tree per acre and canopy coverage ranging from 5 to 100% **Savannas and Upland Forests, 10A, p. 6**
 - 5B. Mature trees absent or generally less than one tree per acre **Prairies, 6A**
 - 6A. Native grass, sedge, and forb community occurring along steep slopes of outwash channels and moraines with south- to west-facing slopes associated with river valleys, streams, or kettle lakes and surrounded by oak forest or oak savanna **Hillside Prairie**
 - 6B. Native grass, sedge, and forb community occurring on rolling moraines, level to undulating outwash plains, and flat lakeplains.
 - 7A. Vegetation generally short (<1.0 m [39 in]) and patchy. Dominant plants include little bluestem (*Andropogon scoparius*), Pennsylvania sedge (*Carex pennsylvanica*), and scattered patches of big bluestem (*Andropogon gerardii*). Occurring on loamy sands on well-drained to excessively well-drained, sandy glacial outwash plains and lakebeds primarily north of the climatic tension zone in the north-central and western Lower Peninsula and occasionally in southern Lower Michigan **Dry Sand Prairie**
 - 7B. Vegetation generally tall (>1.0 m [39 in]) and dense. Dominant plants include big bluestem, little bluestem, and Indian grass (*Sorghastrum nutans*).
 - 8A. Comprised predominantly of upland prairie species but also includes species more commonly associated with wetlands including bluejoint grass (*Calamagrostis canadensis*), cordgrass (*Spartina pectinata*), rushes (*Juncus* spp.), tall flat-top white aster (*Aster umbellatus*), balsam ragwort (*Senecio pauperculus*), and Virginia mountain mint (*Pycnanthemum virginiana*). Occurring on lakeplains, outwash, old glacial lakebeds, abandoned stream channels, and river terraces throughout the Lower Peninsula. Soils sandy loam to loamy sand, occasionally showing evidence of a fluctuating water table such as iron mottling **Mesic Sand Prairie**
 - 8B. Comprised of upland prairie species. Restricted to southern Lower Michigan. Soils do not show evidence of a fluctuating water table.

- 9A. Soils loam or occasionally sandy loam, black to dark brown in color. Cordgrass occasionally subdominant. Other characteristic grasses include porcupine grass (*Stipa spartea*), prairie dropseed (*Sporobolus heterolepis*), and switch grass (*Panicum virgatum*). Occurring on level to slightly undulating glacial outwash in southwestern Lower Michigan ...
..... **Mesic Prairie**
- 9B. Soils loamy sand, sand, or occasionally sandy loams, dark brown to tan in color. Characteristic species include Pennsylvania sedge, bastard toadflax (*Comandra umbellata*), leadplant (*Amorpha canescens*), thimbleweed (*Anemone cylindrica*), black-eyed Susan (*Rudbeckia hirta*), round-headed bush clover (*Lespedeza capitata*), butterfly weed (*Asclepias tuberosa*), and smooth aster (*Aster laevis*). Occurring on both outwash and moraines within range of former oak openings in southern Lower Michigan but most prevalent in southwestern Lower Michigan ..
..... **Dry-mesic Prairie**

Savannas and Upland Forests

- 10A. Tree canopy cover 60% or more with ground flora primarily native forbs, sedges, and grasses associated with forested communities
..... **Upland Forests**, 16A, p. 7
- 10B. Tree canopy cover less than 60% with ground flora primarily native grasses, sedges, forbs, and low shrubs associated with savanna and barrens communities
..... **Savannas**, 11A
- 11A. Mature trees pines or mixture of pine and oak species.
 - 12A. Scattered jack pine (*Pinus banksiana*) or jack pine thickets among native grasses. Ground layer dominated by little bluestem, Pennsylvania sedge, big bluestem, forbs, and low shrubs. Occurring in northern Michigan on excessively drained, sandy outwash plains and lakeplains
..... **Pine Barrens**
 - 12B. Scattered and clumped oak and pine species with ground flora of native grassland species. Mature tree species may include white oak (*Quercus alba*), northern pin oak (*Q. ellipsoidalis*), black oak (*Q. velutina*), white pine (*Pinus strobus*), red pine (*P. resinosa*), jack pine, quaking aspen (*Populus tremuloides*), and black cherry (*Prunus serotina*). Ground layer dominated by little bluestem, Pennsylvania sedge, big bluestem, and forbs and low shrubs. Occurring both north and south of the climatic tension zone on sandy outwash plains, lakeplains, and occasionally coarse-textured end moraines **Oak-Pine Barrens**
- 11B. Mature trees oaks with little to no pine. Located south of the climatic tension zone in southern Lower Michigan.
 - 13A. Scattered bur oak (*Quercus macrocarpa*) among tall prairie grasses occurring historically in southwestern Lower Peninsula on outwash plains and river terraces but now believed extirpated from Michigan. Soils fertile, fine-textured, loam, sandy loam or silt loam
..... **Bur Oak Plains**
 - 13B. Scattered white oak or mixed oak species among tall and short prairie grasses.
 - 14A. Savanna community occurring on sand ridges, level sand plains, and depressions within lakeplains of southeastern Lower Michigan. Soils are very fine-textured sandy loams, loamy sands, or sands. Dominant tree species include white oak and black oak on well-drained soils and bur oak, pin oak (*Quercus palustris*), and swamp white oak (*Quercus bicolor*) in poorly drained depressions **Lakeplain Oak Openings**
 - 14B. Savanna community occurring on moraines and outwash areas primarily within southern Lower Michigan

- 15A. Scattered white oak, bur oak, and chinquapin oak (*Quercus muehlenbergii*), with occasional pignut hickory (*Carya glabra*), shagbark hickory (*C. ovata*), red oak (*Q. rubra*), and black oak among prairie grasses and a mix of prairie and forest ground flora. Prevalent fire-tolerant shrubs include American hazelnut (*Corylus americana*), New Jersey tea (*Ceanothus americanus*), and leadplant (*Amorpha canescens*). Nearly completely extirpated from Michigan but once prevalent in the southern Lower Peninsula on moderately fertile sandy loams and loamy sands of outwash and coarse-textured moraines **Oak Openings**
- 15B. Scattered white oak, black oak, and occasionally northern pin oak among prairie grasses occurring on infertile, droughty soils on glacial outwash and south- to west-facing, steep coarse-textured moraines. Other common trees and shrubs include sassafras (*Sassafras albidum*), black cherry, red maple (*Acer rubrum*), big-toothed aspen (*Populus grandidentata*), quaking aspen, American hazelnut, New Jersey tea, serviceberry (*Amelanchier* spp.), bearberry (*Arctostaphylos uva-ursi*), and sweetfern (*Comptonia peregrina*) **Oak Barrens**

Upland Forests

- 16A. Forested community primarily occurring south of the climatic tension zone in southern Lower Michigan.
 - 17A. Overstory dominated by sugar maple (*Acer saccharum*) and American beech (*Fagus grandifolia*), with abundant red oak, American ash (*Fraxinus americana*), and/or basswood (*Tilia americana*) **Mesic Southern Forest**
 - 17B. Overstory dominated by oaks.
 - 18A. Soils dry-mesic, moderately fertile, slightly acid to neutral sandy loam or loam. Occurring on glacial outwash, coarse-textured moraines, sandy glacial lakeplains, and occasionally kettle-kame topography and sand dunes. Overstory dominated by white oak, black oak, and/or red oak, often with abundant pignut hickory, shagbark hickory, bitternut hickory (*Carya cordiformis*), red maple (*Acer rubrum*), American ash, black cherry, scarlet oak (*Quercus coccinea*), basswood, and/or sassafras (*Sassafras albidum*) **Dry-mesic Southern Forest**
 - 18B. Soils droughty, infertile, medium to strongly acid sand, loamy sand, or sandy loam. Occurring principally on glacial outwash, and less frequently on sand dunes, sandy glacial lakeplains, and coarse-textured moraines. Overstory dominated by black oak and/or white oak with canopy associates including pignut hickory, sassafras, red maple, black cherry, and/or northern pin oak **Dry Southern Forest**
- 16B. Forested community primarily occurring north of the climatic tension zone in northern Lower Michigan and the Upper Peninsula.
 - 19A. Occurring on a repeated pattern of alternating dunes and swales adjacent to the Great Lakes and supporting a mixture of upland and wetland communities **Wooded Dune and Swale Complex**
 - 19B. Not occurring on alternating dunes and swales.
 - 20A. Dominated by northern white-cedar (*Thuja occidentalis*), white spruce (*Picea glauca*), balsam fir (*Abies balsamea*), and paper birch (*Betula papyrifera*). Occurring primarily along northern shorelines of the Great Lakes, on Great Lakes islands, and locally inland **Boreal Forest**

- 20B. Dominated by pines and/or sugar maple, American beech, basswood, hemlock (*Tsuga canadensis*), and yellow birch (*Betula alleghaniensis*).
- 21A. Overstory dominated by sugar maple, hemlock, American beech, basswood, white pine, and/or yellow birch **Mesic Northern Forest**
- 21B. Overstory dominated by pines and/or mixture of pine and oak.
 - 22A. Canopy dominated or codominated by white pine, often with red pine, white oak, black oak, red oak, and/or hemlock. Soils extremely acid to very strongly acid sand or loamy sand. Occurring on sandy glacial outwash, sandy glacial lakeplains, and less often on thin glacial drift over bedrock, inland dune ridges, and coarse-textured moraines **Dry-mesic Northern Forest**
 - 22B. Overstory dominated by jack pine or red pine, or jack pine and northern pin oak. Soils droughty, low nutrient, extremely acid to very strongly acid sands. Occurring on sandy glacial outwash, sandy glacial lakeplains, and sand ridges within peatlands **Dry Northern Forest**

Primary Communities: Bedrock, Cliff, Dune, and Shore Communities

- 23A. Located primarily inland from the Great Lakes shoreline **Inland Bedrock Communities, 37A, p. 9**
- 23B. Located primarily along Great Lakes shoreline **Great Lakes Shoreline Communities, 24A**
 - 24A. Substrate primarily sand or sand and gravel.
 - 25A. Little to no dune development. Very sparsely vegetated with herbaceous forbs and grasses such as sea rocket (*Cakile edentula*), Baltic rush (*Juncus balticus*), silverweed (*Potentilla anserina*), beach pea (*Lathyrus japonicus*), marram grass (*Ammophila breviligulata*), and occasionally Pitcher's thistle (*Cirsium pitcheri*) **Sand and Gravel Beach**
 - 25B. Extensive dune development. Both open and well-vegetated dunes common.
 - 26A. Vegetation primarily grasses and low shrubs such as marram grass, sand reed grass (*Calamovilfa longifolia*), little bluestem, bearberry, creeping juniper (*Juniperus horizontalis*), sand cherry (*Prunus pumila*), willows (*Salix cordata* and *S. myricoides*), and common juniper (*Juniperus communis*) **Open Dunes**
 - 26B. Vegetation primarily evergreen trees and shrubs with scattered or clumped jack pine, white pine, white spruce, and red pine over dense low shrub cover dominated by common juniper, bearberry, ground juniper, and sand cherry and patches of grasses including marram grass, sand reed grass, and little bluestem. Occurring in dune fields and in depressions among dune ridges **Great Lakes Barrens**
 - 24B. Substrate primarily bedrock or cobble-sized rocks.
 - 27A. Bedrock exposed and occurring as nearly level formations or vertical cliffs.
 - 28A. Level or slightly tilted exposed bedrock along lakeshores.
 - 29A. Located along northern Lakes Michigan and Huron on the Niagaran Escarpment in the eastern Upper Peninsula. Sparse cover of native vegetation on limestone and/or dolomite bedrock **Limestone Bedrock Lakeshore**
 - 29B. Located along Lake Superior. Sparse cover of native vegetation on volcanic, granitic, metamorphic, or sandstone bedrock.
 - 30A. Substrate primarily sandstone bedrock **Sandstone Bedrock Lakeshore**
 - 30B. Substrate primarily volcanic or granitic bedrock.

- 31A. Substrate primarily volcanic in origin including basalt and volcanic conglomerate bedrocks
..... **Volcanic Bedrock Lakeshore**
- 31B. Substrate primarily granitic bedrock, which may include granite, quartzite, schist, gabbro, gneiss, and a diversity of other resistant igneous and metamorphic rock types
..... **Granite Bedrock Lakeshore**
- 28B. Vertical or nearly vertical exposure of bedrock cliff along lakeshore.
 - 32A. Located primarily along northern Lakes Michigan and Huron on the Niagaran Escarpment in the eastern Upper Peninsula. Sparse cover of native vegetation on limestone and/or dolomite bedrock
..... **Limestone Lakeshore Cliff**
 - 32B. Located primarily along Lake Superior. Sparse cover of native vegetation on sandstone, granitic, or volcanic bedrock.
 - 33A. Substrate primarily sandstone bedrock
..... **Sandstone Lakeshore Cliff**
 - 33B. Substrate primarily volcanic or granitic bedrock.
 - 34A. Lakeshore cliff primarily composed of volcanic bedrock including basalt and volcanic conglomerate**Volcanic Lakeshore Cliff**
 - 34B. Lakeshore cliff primarily composed of granitic bedrock, which may include granite, quartzite, schist, gabbro, gneiss, and a diversity of other resistant metamorphic rock types
..... **Granite Lakeshore Cliff**
- 27B. Cobble-sized rocks with little soil development or exposed bedrock.
 - 35A. Located along northern Lakes Michigan and Huron. Sparse cover of native vegetation on cobble comprised chiefly of limestone and/or dolomite **Limestone Cobble Shore**
 - 35B. Located primarily along Lake Superior. Comprised chiefly of sandstone or volcanic granitic cobble, typically with inclusions of granitic rock types.
 - 36A. Sparse cover of native vegetation on cobble comprised chiefly of sandstone **Sandstone Cobble Shore**
 - 36B. Sparse cover of native vegetation on cobble comprised chiefly of volcanic rocks including basalt and volcanic conglomerates **Volcanic Cobble Shore**

Inland Bedrock Communities

- 37A. Bedrock vertical or nearly vertical cliffs.
 - 38A. Occurring primarily on the Niagaran Escarpment in the eastern and south-central Upper Peninsula and rarely in the western Upper Peninsula and northeastern Lower Michigan. Sparse vegetation cover on limestone and/or dolomite bedrock including Kona dolomite in Marquette County
..... **Limestone Cliff**
 - 38B. Occurring primarily in the western and north-central Upper Peninsula and very rarely in the Lower Peninsula. Sparse vegetation cover on sandstone, granitic, or volcanic bedrock.
 - 39A. Substrate primarily sandstone bedrock **Sandstone Cliff**
 - 39B. Substrate primarily granitic or volcanic bedrock.
 - 40A. Cliff primarily composed of volcanic bedrock including basalt and volcanic conglomerate **Volcanic Cliff**
 - 40B. Cliff primarily composed of granitic bedrock, which may include granite, quartzite, schist, gabbro, gneiss, and a diversity of other resistant igneous and metamorphic rock types
..... **Granite Cliff**
- 37B. Bedrock level to steeply sloped with thin soils.

- 41A. Community structure open, native grasses dominant, with limited encroachment of trees and shrubs. Thin soils over limestone or dolomite bedrock. Occurring on the Niagaran Escarpment in the eastern and south-central Upper Peninsula and northeastern Lower Peninsula **Alvar**
- 41B. Community structure savanna-like with scattered native trees and shrubs.
 - 42A. Positioned on the tops of high bedrock escarpments in the western Upper Peninsula. Low shrubs, flagged trees, and dwarfed misshapen trees distorted into a krummholz growth form are common. Prevalent species include bearberry, common juniper, creeping juniper, rusty woodsia (*Woodsia ilvensis*), maidenhair spleenwort (*Asplenium trichomanes*), red oak, white pine, northern white-cedar, and big-toothed aspen **Northern Bald**
 - 42B. Positioned on areas of exposed bedrock in nearly level to steep topography.
 - 43A. Located primarily along the Niagaran Escarpment in the eastern Upper Peninsula and northeastern Lower Peninsula. Substrate level to slightly tilted or occasionally stair-stepped with thin soils over limestone and/or dolomite bedrock **Limestone Bedrock Glade**
 - 43B. Located primarily in the western Upper Peninsula. Substrate level to steep or stair-stepped with thin soils and areas of exposed granitic or volcanic bedrock.
 - 44A. Substrate primarily granitic bedrock, which may include granite, schist, gabbro, gneiss, slate, and a diversity of other resistant igneous and metamorphic rock types. Distributed primarily in northern Marquette County **Granite Bedrock Glade**
 - 44B. Substrate primarily volcanic in origin including basalt and volcanic conglomerate bedrock. Distributed more broadly in northern Marquette County, Isle Royale, Keweenaw Peninsula, and elsewhere in the western Upper Peninsula **Volcanic Bedrock Glade**

Wetland Communities

- 45A. Forested or tall shrub-dominated wetland. Mature trees contributing greater than 25% overall canopy cover and/or tall shrubs (> 1.5 m [5 ft]) contributing more than 50% canopy cover **Forested and Shrub Wetlands, 66A, p. 14**
- 45B. Open (non-forested) wetland. Mature trees absent or contributing 25% or less overall canopy cover and/or tall shrubs (> 1.5 m [5 ft]) absent or contributing 50% or less canopy cover **Open (non-forested) Wetlands, 46A**
- 46A. Occurrence limited to shorelines of the Great Lakes and areas strongly influenced by Great Lakes water level fluctuation and processes such as connecting channels, river mouths, and dune fields.
 - 47A. Vegetation forms distinct zones that typically include submergent marsh, emergent marsh, and wet meadow, with shrub and forested wetlands common inland from the shoreline. Submergent marsh and emergent marsh zones typically extend into open water, greater than 1 m (39 in) deep, of Great Lakes, connecting channels, or river mouths **Great Lakes Marsh**
 - 47B. Vegetation zonation less pronounced and not extending into open water, greater than 1 m (39 in) deep, of Great Lakes, connecting channels, or river mouths.
 - 48A. Located in protected bays and abandoned coastal embayments along the shorelines of northern Lake Huron and Lake Michigan. Soils grade from calcareous sand or clay along shoreline to alkaline marl and organic deposits farther inland. Vegetation comprised of sedges, rushes, and calciphiles including spike-rushes (*Eleocharis elliptica* and *E. rostellata*), false asphodel (*Tofieldia glutinosa*), low calamint (*Calamintha arkansana*), Kalm's lobelia (*Lobelia kalmii*), grass-of-Parnassus (*Parnassia glauca*), Indian paintbrush (*Castilleja coccinea*), dwarf Canadian primrose (*Primula mistassinica*), small fringed gentian (*Gentianopsis procera*), small yellow lady's-slipper (*Cypripedium calceolus* var. *parviflorum*), white camas (*Zigadenus glaucus*), and shrubby cinquefoil (*Potentilla fruticosa*) **Coastal Fen**

- 48B. Located in depressions in open dunes or between dune ridges including wind-formed depressions at the base of blowouts, hollows of open dune fields, and abandoned river channels that once flowed parallel to the lakeshore behind a foredune. Sandy soils are neutral to moderately alkaline sand sometimes covered by a thin layer of muck or marl. Vegetation dominated by rushes, sedges, and shrubs including Baltic rush, twig-rush (*Cladium mariscoides*), golden-seeded spike-rush (*Eleocharis elliptica*), beak-rush (*Rhynchospora capillacea*), sedges (*Carex aquatilis*, *C. garberi*, *C. viridula*, *C. lasiocarpa*), and shrubby cinquefoil, with calciphiles well represented **Interdunal Wetland**
- 46B. Occurrence more broadly distributed. Found along Great Lakes' shorelines and/or inland.
- 49A. Vegetation dominated by grasses, with sedges important but generally not dominant.
- 50A. Distribution limited to glacial lakeplain in southeastern or southwestern Lower Michigan. Occurring on lakeplains both along Great Lakes shoreline and inland.
- 51A. Vegetation dominated by big bluestem, switch grass, little bluestem, and/or Indian grass. Common species typically include sedges (*Carex* spp.), Ohio goldenrod (*Solidago ohioensis*), Riddell's goldenrod (*Solidago riddellii*), Virginia mountain mint (*Pycnanthemum virginianum*), swamp betony (*Pedicularis lanceolata*), marsh blazing star (*Liatris spicata*), colic root, (*Aletris farinosa*), tall coreopsis (*Coreopsis tripteris*), and ironweed (*Vernonia* spp.) **Lakeplain Wet-mesic Prairie**
- 51B. Vegetation dominated by bluejoint grass and cordgrass. Common species typically include sedges (*Carex stricta*, *C. pellita*, *C. aquatilis*), Baltic rush, twig-rush, and swamp milkweed (*Asclepias incarnata*) **Lakeplain Wet Prairie**
- 50B. Distribution broader. Occurring inland on outwash plains, old glacial lakebeds, abandoned stream channels, and river terraces.
- 52A. Soils sand to sandy loam. Occurring in both northern and southern Lower Michigan. Dominant grasses may include big bluestem, little bluestem, Indian grass, bluejoint grass, cordgrass, and prairie dropseed (*Sporobolus heterolepis*). Tussock sedge (*Carex stricta*) may be locally dominant **Wet-mesic Sand Prairie**
- 52B. Soils loam to silt loam. Occurring in southern Lower Michigan.
- 53A. Dominant grasses include big bluestem and Indian grass, with bluejoint grass, cordgrass, and tussock sedge locally common **Wet-mesic Prairie**
- 53B. Dominant grasses include bluejoint grass and cordgrass, with tussock sedge locally dominant **Wet Prairie**
- 49B. Vegetation dominated by submergent plants or cat-tails, sedges, bulrushes, and/or sphagnum mosses and ericaceous shrubs, with grasses important but generally not dominant.
- 54A. Standing water greater than 6 in (15 cm) deep usually present throughout the growing season.
- 55A. Vegetation primarily submergent with leaves submerged or with leaves primarily submergent or floating on water surface during growing season. Occurring within shallow to occasionally deep waters of lakes and streams. Common submergent and floating-leaved plants include common waterweed (*Elodea canadensis*), water star-grass (*Heteranthera dubia*), milfoils (*Myriophyllum* spp.), naiads (*Najas* spp.), pondweeds (*Potamogeton* spp.), water crowfoots (*Ranunculus* spp.), wild-celery (*Vallisneria americana*), stoneworts (*Chara* spp. and *Mitella* spp.), honewort (*Ceratophyllum demersum*), bladderworts (*Utricularia* spp.), water lily (*Nymphaea odorata*), yellow pond-lily (*Nuphar* spp.), and water shield (*Brasenia schreberi*) **Submergent Marsh**
- 55B. Vegetation primarily emergent with leaves protruding above the water (when present) during growing season. Occurring along the shores of lakes and streams or in depressions where standing water occurs throughout the year. Common emergent plants include cat-tails (*Typha angustifolia*, *T. latifolia*), bulrushes (*Schoenoplectus* spp.), sedges (*Carex* spp.), manna grass (*Glyceria* spp.), bur-reed (*Sparganium* spp.), water-plantain (*Alisma plantago-aquatica*), spike-rush (*Eleocharis* spp.), cut grass (*Leersia oryzoides*), and wild rice (*Zizania* spp.) **Emergent Marsh**

- 54B. Standing water absent or typically less than 6 in (15 cm) deep during mid-summer and early fall, but soil usually remaining saturated throughout the year. May occur in poorly drained outwash and lakeplains, isolated depressions associated with moraines or ice-contact topography, or along the shores of lakes and rivers.
- 56A. Soil saturated by sodium- and chloride-laden groundwater from natural brine aquifers. Common indicator plants include Olney three-square (*Schoenoplectus americanus*), dwarf spike-rush, (*Eleocharis parvula*), spearscale (*Atriplex patula*), and purslane (*Portulaca oleracea*) **Inland Salt Marsh**
- 56B. Soil saturated but not by sodium- and chloride-laden groundwater from natural brine aquifers.
- 57A. Community structure characterized by a repeated, alternating pattern of low peat rises (strings) and hollows (flarks). Strings may support scattered and stunted black spruce (*Picea mariana*) and tamarack (*Larix laricina*), low shrubs including bog birch (*Betula pumila*), shrubby cinquefoil, bog rosemary (*Andromeda glaucophylla*), leatherleaf (*Chamaedaphne calyculata*), and sedges (*Carex oligosperma* *C. limosa*, *C. lasiocarpa*). The alternating flarks are often inundated and may support open lawns of sphagnum mosses, sedges (*Carex oligosperma* *C. limosa*, *C. exilis*), common bog arrow grass (*Triglochin maritima*), and arrow grass (*Scheuchzeria palustris*). Soils are deep peat and slightly acid to circumneutral **Patterned Fen**
- 57B. Community structure lacks repeating pattern of low peat rises and alternating hollows.
- 58A. Ground layer dominated by a continuous carpet of sphagnum mosses, or sphagnum mosses locally dominant on scattered low peat mounds.
- 59A. Trees canopy cover typically 10 to 25%, consisting of scattered and stunted black spruce and tamarack. Occurring north of the climatic tension zone, predominantly in the Upper Peninsula and rarely in northern Lower Michigan .. **Muskeg**
- 59B. Trees absent or occurring in localized areas of wetland with overall canopy cover typically less than 10%.
- 60A. Vegetation dominated by low, ericaceous shrubs such as leatherleaf, bog rosemary, Labrador tea (*Ledum groenlandicum*), and cranberry (*Vaccinium oxycoccos* and *V. macrocarpon*). Soil very strongly acidic, fibric peat. Occurring statewide but uncommon in southern Lower Michigan **Bog**
- 60B. Vegetation dominated by few-seed sedge (*Carex oligosperma*) and/or wiregrass sedge (*C. lasiocarpa*), often with sphagnum either throughout ground layer or dominating widely scattered, low peat mounds, along with ericaceous shrubs and stunted conifers. Soils very strongly to strongly acidic, saturated deep fibric peat. Hydrology moderately influenced by groundwater flow. Occurring north of the climatic tension zone in kettle depressions and on level areas or shallow depressions of glacial outwash and lakeplains **Poor Fen**
- 58B. Ground layer dominated by sedges, rushes, grasses, and/or forbs with sphagnum mosses absent or occurring locally.
- 61A. Soils mineral or occasionally shallow muck (< 1 m [39 in]) over sand or loamy sand with underlying clay lenses occasionally present. Occupies perimeters or entire basins of softwater seepage lakes and other isolated depressions characterized by large water table fluctuations (both seasonally and from year to year).

- 62A. Atlantic and Gulf coastal plain disjunct plants common to locally dominant. Soils strongly acidic to very strongly acidic **Coastal Plain Marsh**
- 62B. Atlantic and Gulf coastal plain disjuncts plants absent or rare. Soils neutral to very strongly acidic **Intermittent Wetland**
- 61B. Soils typically deep peat (> 1 m [39 in]). Occupying depressions in glacial lakeplains and outwash plains, abandoned glacial lakebeds, stream corridors, and margins of lakes.
- 63A. Dominated by sedges, particularly tussock sedge (*Carex stricta*), wiregrass sedge (*C. lasiocarpa*), and/or lake sedge (*C. lacustris*), with bluejoint grass occasionally codominant. Vegetation zonation weak.
- 64A. Located north of the climatic tension zone in northern Lower Michigan and the Upper Peninsula. Vegetation dominated by sedges (*Carex stricta*, *C. lacustris*, *C. lasiocarpa*, *C. rostrata*, and/or *C. vesicaria*). Other important species include bluejoint grass, fringed brome (*Bromus ciliatus*), rattlesnake grass (*Glyceria canadensis*), marsh wild-timothy (*Muhlenbergia glomerata*), and green bulrush (*Scirpus atrovirens*). Soils are neutral to strongly acidic, shallow to deep peat. Frequently invaded by tag alder (*Alnus rugosa*), forming northern shrub thicket **Northern Wet Meadow**
- 64B. Located south of the climatic tension zone in southern Lower Michigan. Vegetation dominated by tussock sedge and sometimes by wiregrass sedge and lake sedge. Other important species include bluejoint grass, sedges (*Carex aquatilis*, *C. comosa*, *C. prairea*, *C. rostrata*), fringed brome, marsh wild timothy, joe-pye-weed (*Eupatorium maculatum*), and common boneset (*E. perfoliatum*). Soils are typically neutral to mildly alkaline peat. Frequently invaded by dogwoods (*Cornus* spp.), willows (*Salix* spp.), and meadowsweet (*Spiraea alba*), forming southern shrub-carr ... **Southern Wet Meadow**
- 63B. Dominance shared by sedges, grasses, rushes, bulrushes, and forbs. Scattered conifers and shrubs common. Soils neutral to moderately alkaline deep peat or marl. Vegetation sparse where marl covers the surface. Vegetation zonation well developed and strongly influenced by surface and subsurface groundwater seepage. Calciphiles well represented including Kalm's lobelia, Ohio goldenrod, bog goldenrod (*S. uliginosa*), false asphodel, grass-of-Parnassus (*Parnassia glauca*), beak-rushes (*Rhynchospora alba* and *R. capillacea*), bog arrow-grass (*Triglochin maritimum*), twig-rush (*Cladium mariscoides*), rush (*Juncus brachycephalus*), golden-seeded spike-rush (*Eleocharis elliptica*), beaked spike-rush (*Eleocharis rostellata*), white camas (*Zigadenus glauca*), shrubby cinquefoil, and alder-leaved buckthorn (*Rhamnus alnifolia*).

- 65A. Located north of the climatic tension zone in northern Lower Michigan and the Upper Peninsula. Additional common species include sedges (*Carex lasiocarpa*, *C. chordorrhiza*, *C. leptalea*, *C. limosa*, *C. livida*, and *C. sterilis*), hair grass, twig-rush, sheathed cotton-grass (*Eriophorum spissum*), sweet gale (*Myrica gale*), northern white-cedar, and tamarack **Northern Fen**
- 65B. Located south of the climatic tension zone in southern Lower Michigan, primarily in interlobate regions. Additional common species include sedges (*Carex stricta*, *C. sterilis*, *C. lasiocarpa*, *C. buxbaumii*, *C. prairea*), big bluestem, little bluestem, Indian grass, tall flat-top white aster, whorled loosestrife (*Lysimachia quadriflora*), Virginia mountain mint (*Pycnanthemum virginianum*), Riddell's goldenrod, sage willow (*Salix candida*), poison sumac (*Toxicodendron vernix*), and tamarack .. **Prairie Fen**

Forested and Shrub Wetlands

- 66A. Mature trees contributing 25% or less overall canopy cover. Tall shrubs (> 1.5 m [5 ft]) dominant, contributing greater than 50% overall canopy cover **Shrub Wetlands**, 76A, p. 16
- 66B. Mature trees contributing greater than 25% overall canopy cover **Forested Wetlands**, 67A
- 67A. Conifers important, common to dominant in canopy layer.
 - 68A. Conifers overwhelmingly dominant.
 - 69A. Canopy strongly dominated by black spruce, frequently with tamarack, and occasionally with jack pine as codominants. Substrate extremely acid to very strongly acid, deep fibric peat. Sphagnum mosses dominant in ground layer. Ericaceous shrubs dominant to locally abundant including leatherleaf, Labrador tea, bog laurel (*Kalmia polifolia*), and in southern Lower Michigan, smooth highbush blueberry (*Vaccinium corymbosum*). Hydrology strongly influenced by precipitation (i.e., ombrotrophic) due to peat accumulation above groundwater table. Occurring mostly north of the climatic tension zone in depressions of glacial outwash, glacial lakeplains, ground moraine, and kettles in coarse-textured moraines and ice-contact topography **Poor Conifer Swamp**
 - 69B. Canopy strongly dominated by northern white-cedar or tamarack.
 - 70A. Occurring primarily north of the climatic tension zone in northern Lower Michigan and the Upper Peninsula and rarely in southern Lower Michigan. Canopy strongly dominated by northern white-cedar. Tall shrub layer typically sparse. Substrate very strongly acid to moderately alkaline woody peat, with subsurface peat typically circumneutral to moderately alkaline. Hydrology strongly influenced by groundwater movement **Rich Conifer Swamp**
 - 70B. Occurring primarily south of the climatic tension zone in southern Lower Michigan. Canopy strongly dominated by tamarack. Tall shrub layer typically well developed with winterberry (*Ilex verticillata*) and poison sumac common to abundant. Substrate neutral to moderately alkaline, deep peat (> 1 m [39 in]), often containing a layer of marl within soil profile. Hydrology strongly influenced by groundwater movement **Rich Tamarack Swamp**

- 68B. Conifers codominant or subdominant to hardwoods.
 - 71A. Occurring statewide in floodplains of 3rd order or greater streams and rivers. Typically dominated by hardwoods such as silver maple (*Acer saccharinum*) and green ash (*Fraxinus pennsylvanica*), but conifers (tamarack, northern white-cedar, white pine, and hemlock) become important north of the climatic tension zone, where organic soils accumulate in areas of groundwater seepage, backswamps, and meander scars. Other important hardwoods associated with floodplain conifers include black ash, yellow birch, red maple, and basswood .
..... **Floodplain Forest**
 - 71B. Occurring along headwater streams (1st and 2nd orders), and on poorly drained glacial outwash, lakeplain, and moraines.
 - 72A. Tamarack occasional to absent. Overall canopy comprised of a mixture of hardwood and conifer species but either may be locally dominant. Common trees include yellow birch, black ash, red maple, American elm, hemlock, northern white-cedar, white pine, and tamarack. Substrate neutral to strongly acid, deep to shallow peat. Tall shrub layer poorly developed. Hydrology influenced by groundwater movement. Occurring statewide **Hardwood-Conifer Swamp**
 - 72B. Tamarack dominant. Canopy associates include white pine, black ash, yellow birch, red maple, swamp white oak, and American elm. Substrate neutral to moderately alkaline, deep peat (> 1 m [3.3 ft]), often containing a marl layer within soil profile. Tall shrub layer typically well developed with winterberry and poison sumac common to abundant. Hydrology strongly influenced by groundwater movement. Occurring primarily south of the climatic tension zone in southern Lower Michigan. In interlobate regions, is often associated with prairie fen **Rich Tamarack Swamp**
- 67B. Conifers absent or rare in canopy layer. Hardwoods dominant throughout.
 - 73A. Occurring in floodplains of 3rd order or greater streams and rivers. Dominant overstory species include silver maple, red ash, black willow (*Salix nigra*), cottonwood (*Populus deltoides*), basswood, swamp white oak, bur oak, shagbark hickory, sycamore (*Platanus occidentalis*), and hackberry (*Celtis occidentalis*). Where organic soil accumulates in areas such as groundwater seepages, backswamps, and meander scars, tree species may include black ash, yellow birch, red maple, and conifers (tamarack, northern white-cedar, white pine, and hemlock), especially north of the tension zone
..... **Floodplain Forest**
 - 73B. Occurring along headwater streams (1st and 2nd orders), and on poorly drained glacial outwash, lakeplain, and/or depressions in moraines or ice-contact topography.
 - 74A. Distributed north of the climatic tension zone in northern Lower Michigan and the Upper Peninsula. Canopy dominated by black ash with lesser importance of red maple, American elm, silver maple, yellow birch, basswood, green ash, balsam fir, and northern white-cedar. Soils are neutral to slightly acidic, hydric, mineral soils and shallow muck over mineral soils. Occurring on poorly drained lakeplains, outwash plains, and fine- to medium-textured glacial till
..... **Northern Hardwood Swamp**
 - 74B. Distributed south of the climatic tension zone in southern Lower Michigan.

- 75A. Located almost exclusively on level lakeplain in southeastern Lower Michigan. Dominant tree species comprised of highly diverse mixture of lowland and upland hardwoods including oaks, hickories, maples, ashes, and basswood. Soils typically medium to slightly acid sandy loam or loam over mildly alkaline clay **Wet-mesic Flatwoods**
- 75B. Located in depressions on glacial outwash, moraines, and lakeplain throughout southern Lower Michigan. Dominant tree species comprised of lowland hardwoods including silver maple, red maple, red ash, black ash, swamp white oak, bur oak, and occasionally pin oak. Soils mineral or organic, typically neutral to mildly alkaline pH **Southern Hardwood Swamp**

Shrub Wetlands

- 76A. Dominated by buttonbush (*Cephalanthus occidentalis*). Typically occurring in small, isolated depressions south of the climatic tension zone in southern Lower Michigan. Standing water often present throughout growing season **Inundated Shrub Swamp**
- 76B. Dominated by shrub species other than buttonbush.
 - 77A. Shrub canopy dominated by tag alder. Occurring predominantly north of the climatic tension zone in northern Lower Michigan and the Upper Peninsula along streams and lake edges, on outwash channels, outwash plains, and lakeplains **Northern Shrub Thicket**
 - 77B. Shrub canopy dominated by dogwood and willow species such as red-osier dogwood (*C. stolonifera*), gray dogwood (*C. foemina*), silky dogwood (*C. amomum*), Bebb’s willow (*Salix bebbiana*), pussy willow (*S. discolor*), sandbar willow (*S. exigua*), and slender willow (*S. petiolaris*) along with other common shrubs such as bog birch, winterberry, swamp rose (*Rosa palustris*), and red elderberry (*Sambucus racemosa*). Occurring predominantly south of the climatic tension zone in southern Lower Michigan on outwash channels, outwash plains, and lakeplains **Southern Shrub-Carr**

Soil pH Ranges

below 4.5	extremely acid
4.5 – 5.0	very strongly acid
5.1 – 5.5	strongly acid
5.6 – 6.0	medium acid
6.1 – 6.5	slightly acid
6.6 – 7.3	neutral
7.4 – 7.8	mildly alkaline
7.9 – 8.4	moderately alkaline
8.5 – 9.0	strongly alkaline
above 9.0	very strongly alkaline

Community Descriptions

PALUSTRINE COMMUNITIES

MARSH COMMUNITIES

Submergent Marsh

Global/State Rank: GU/S4

Overview

Submergent marsh is an herbaceous plant community that occurs in deep to sometimes shallow water in lakes and streams throughout Michigan. Soils are characterized by loosely consolidated organics of variable depth that range from acid to alkaline and accumulate over all types of mineral soil, even bedrock. Submergent vegetation is composed of both rooted and non-rooted submergent plants, rooted floating-leaved plants, and non-rooted floating plants. Common submergent plants include common waterweed (*Elodea canadensis*), water star-grass (*Heteranthera dubia*), milfoils (*Myriophyllum* spp.), naiads (*Najas* spp.), pondweeds (*Potamogeton* spp.), stoneworts (*Chara* spp. and *Nitella* spp.), coontail (*Ceratophyllum demersum*), bladderworts (*Utricularia* spp.), and water-celery (*Vallisneria americana*).

Landscape Context

Submergent marsh occurs as a zone along the shore of large lakes, or it can cover the entire surface of small, shallow lakes and ponds. In clear lakes, submergent vegetation can persist in water greater than ten meters deep. Submergent vegetation can also form dense beds along the margins of slow-moving streams, or form open, less diverse plant beds in more rapidly flowing streams.

Soils

Loose, poorly consolidated organic soils characterize most submergent plant beds, which can establish on almost all types of mineral soil, and even over bedrock. Such organic soils can be meters thick and are often easily eroded by boat traffic. In the more acid, low nutrient lakes, the accumulation of organic sediments can be minimal, but this is quite variable. The pH of organic sediments can range from acid to alkaline and is largely dependent on the pH of the lake or stream water and underlying mineral substrate.

Natural Processes

Natural water-level fluctuations, fauna, storm waves, and currents all create conditions important for plant regeneration. For example, water shield (*Brasenia schreberi*) produces seed only when water levels drop, leaving plants stranded, and submergent bulrush (*Schoenoplectus subterminalis*) only fruits when water levels are shallow enough for it to produce emergent stems. Establishment of submergent plants is also affected by substrate changes initiated by fish nests and waterfowl feeding; these openings and depressions created by fauna create substrate and light heterogeneity that facilitate plant colonization. Beaver play an integral role in the creation and maintenance of submergent marshes as the community often establishes along channels and ponds generated by beaver flooding. Storm waves and currents are important for distributing seeds and asexual propagules, as well as altering sediment conditions.

Vegetation

Dominant plants include both rooted and non-rooted submergent plants, rooted floating-leaved plants, and non-rooted floating plants. Some of the more widely distributed rooted submergent plants are common waterweed, water star-grass, milfoils, naiads, pondweeds (nearly 30 species), water crowfoots, water-celery, and stoneworts. A few submergent plants are non-rooted, including the extremely widespread coontail and several of the carnivorous bladderworts (*Utricularia vulgaris*, *U. intermedia*, and *U. gibba*). Most observers are familiar with the showy rooted floating-leaved plants, which include sweet-scented water-lily (*Nymphaea odorata*), yellow pond-lily (*Nuphar variegata* and *N. advena*), and water shield (*Brasenia schreberi*). Some of the less conspicuous plants of the submergent marsh are the non-rooted floating plants, including small duckweed (*Lemna minor*), star duckweed (*L. trisulca*), great duckweed (*Spirodela polyrhiza*), and water meal (*Wolffia* spp.).

Submergent marshes can exhibit distinct zonation. Floating-leaved waterlilies and yellow pond-lilies are often concentrated along the shallow organic-rich margins of submergent marshes, while pondweeds, including *Potamogeton amplifolius*, *P. praelongus*, *P. illinoensis*, *P. zosteriformis*, *P. friesii*, and *P. strictifolius* can grow in water five meters deep or greater. Other submergent plants of the deep marsh include wild celery and common waterweed. The stoneworts, actually green algae, are able to persist in far deeper water than most flowering aquatic plants, often forming a low, lawn-like mat to as much as 40 meters below the surface.

Noteworthy Animals

Submergent marshes provide habitat to a broad diversity of aquatic invertebrates, many of which occupy and feed on decomposing vegetation. The invertebrates support numerous species of fish, amphibians, reptiles, waterfowl, water birds, and wetland mammals like muskrat (*Ondatra zibethicus*). Muskrats and beaver (*Castor canadensis*) can profoundly influence the hydrology of submergent marshes and surrounding wetlands. Muskrats create open water channels and beavers can cause substantial flooding through their dam-building activities. Specific submergent plants can be critical to fauna. For example, loss of water-celery from the Detroit River resulted in major declines in redheads (*Aythya americana*) and other diving ducks.

Rare Plants

Lemna valdiviana (pale duckweed, presumed extirpated from Michigan)
Littorella uniflora (American shore-grass, state special concern)
Myriophyllum alterniflorum (alternate-leaved water-milfoil, state special concern)
Planorbella smithi (aquatic snail, endangered)
Potamogeton confervoides (alga pondweed, state special concern)
Potamogeton pulcher (spotted pondweed, state endangered)
Potamogeton vaseyi (Vasey's pondweed, state threatened)
Ruppia maritima (widgeon-grass, state threatened)
Subularia aquatica (awlwort, state endangered)

Rare Animals

Lepisosteus oculatus (spotted gar, state special concern)
Siren intermedia nettingi (western lesser siren, state special concern)

Biodiversity Management Considerations

Maintaining low levels of boat traffic and eliminating nutrient and sediment inputs, dredging activity, and invasive species populations is integral to protecting the ecological integrity of high-quality submergent marsh. Especially on small northern lakes, motorboat propellers and the discharge from jet skis and personal watercraft can disturb the loose substrates of submergent

marshes, eventually eliminating vegetation. Zebra mussels (*Dreissena polymorpha*) have altered the chemistry of many aquatic habitats, modifying habitat for aquatic plants, often increasing the amount of submergent vegetation in turbid, nutrient-rich waters. Invasive aquatic plants such as Eurasian water-milfoil (*Myriophyllum spicatum*) now dominate portions of many lakes and slow-flowing rivers throughout Michigan, especially in the Lower Peninsula. Its dense growth can result in the loss of other aquatic plant species, eliminate habitat for fish, invertebrates, and wildlife, and degrade water quality. Another aggressive invasive aquatic, frogbit (*Hydrocharis morsus-ranae*), is currently known from only a few locations in southeastern Michigan, and efforts to restrict its spread should be undertaken while its distribution in Michigan is still limited. Similarly, hydrilla (*Hydrilla verticillata*) has aggressively colonized submergent marshes and outcompeted native submergent plants in nearby states, highlighting the importance of monitoring to prevent its spread in Michigan waterways. Propagules of aquatic plants are often unintentionally spread by watercraft moving among lakes and rivers, and boaters are strongly encouraged to inspect and rinse their boats after use. Both native and invasive aquatic plants can respond with increased growth to nutrient input in the form of runoff from agricultural fields and lawns, leaking septic systems, and sewage discharge. Long-term, increased nutrient inputs can lead to lake eutrophication, algal blooms, and loss of aquatic plant and animal diversity. Dredging for marl has destroyed many marshes along the edges of small lakes in the eastern Upper Peninsula and portions of Lower Michigan.

Variation

A shallow water type in northern softwater, acid lakes is composed of several rosette-forming species, such as pipewort (*Eriocaulon septangulare*), quillwort (*Isoetes* spp.), American shore-grass (*Littorella uniflora*), brown-fruited rush (*Juncus pelocarpus*), water lobelia (*Lobelia dortmanna*), and water-milfoil (*Myriophyllum tenellum*). Great Lakes coastal marshes often contain a zone of submergent vegetation in deeper water, beyond the emergent marsh zone.

Similar Natural Communities

Emergent marsh, intermittent wetland, and Great Lakes marsh.

Relevant Literature

- Albert, D.A. 2003. Between land and lake: Michigan's Great Lakes coastal wetlands. Michigan Natural Features Inventory. Michigan State University Extension, East Lansing, MI. Bulletin E-2902. 96 pp.
- Cronk, J.K., and M. Siobhan Fennessy. 2001. Wetland plants: Biology and ecology. Lewis Publishers, Boca Raton, FL. 462 pp.
- Faber-Langendoen, D., ed. 2001. Plant communities of the Midwest: Classification in an ecological context. Association for Biodiversity Information, Arlington, VA. 61 pp. + appendix (705 pp.).
- Hutchinson, G.E. 1975. A treatise on limnology. Volume 3. Limnological botany. John Wiley and Sons, New York, NY. 660 pp.

Emergent Marsh

Global/State Rank: GU/S4

Overview

Emergent marsh is a shallow-water wetland along the shores of lakes and streams characterized by emergent narrow- and broad-leaved herbs and grass-like plants as well as floating-leaved herbs. Common plants include water plantain (*Alisma plantago-aquatica*), sedges (*Carex* spp.), spike-rushes (*Eleocharis* spp.), pond-lilies (*Nuphar* spp.), pickerel weed (*Pontederia cordata*), arrowheads (*Sagittaria* spp.), bulrushes (*Schoenoplectus* spp.), and cat-tails (*Typha* spp.). The community occurs on both mineral and organic soils.

Landscape Context

Michigan's landscape is the result of recent continental glaciation, creating thousands of lake basins, drainage networks, and poorly drained depressions that support wetland vegetation. Emergent marshes line the margins of many streams and inland lakes, as well as protected portions of the Great Lakes shoreline, where it is classified as Great Lakes marsh.

Soils

Emergent marsh can develop on all textures of glacial sediment, including rock, gravel, sand, silt, or clay. Typically there is an accumulation of circumneutral to alkaline, fine organic sediments overlying the mineral soil. Where organic sediments are acid, the wetlands tend to develop into peatlands rather than remain as marsh.

Natural Processes

Emergent marshes are subject to frequent or seasonal flooding. Periods of low water facilitate seed bank expression and seedling establishment when litter levels are low. Beaver dams in nearby streams cause major changes to soils and vegetation. One of the most important results of flooding is the creation of oxygen-deprived sediments and accumulation of peat. Muskrat feeding within emergent marshes can create openings that are colonized by submergent and floating vegetation. Historically, where emergent marshes bordered fire-dependent uplands, wildfires likely burned across the community, reducing litter levels and facilitating seed bank expression and seedling establishment.

Vegetation

Emergent marsh is a broad wetland type, characterized by a wide diversity of emergent and floating-leaved plant species. Some of the more common species and genera include water plantain (*Alisma plantago-aquatica*), sedges (*Carex comosa*, *C. lacustris*, *C. lasiocarpa*, *C. oligosperma*, *C. stricta*, and many more), spike-rushes (*Eleocharis acicularis*, *E. elliptica*, *E. equisetoides*, *E. obtusa*, *E. quinqueflora*, *E. smallii*, and others), manna grass (i.e., *Glyceria borealis*, *G. canadensis*, and *G. striata*), cut grass (*Leersia oryzoides*), small duckweed (*Lemna minor*), yellow pond-lily (*Nuphar advena* and *N. variegata*), sweet-scented water-lily (*Nymphaea odorata*), smartweeds (*Polygonum amphibium*, *P. hydropiper*, *P. lapathifolium*, and others), pickerel weed (*Pontederia cordata*), arrowheads (*Sagittaria graminea*, *S. latifolia*, *S. montevidensis*, and *S. rigida*), bulrushes (*Schoenoplectus acutus*, *S. pungens*, *S. subterminalis*, and *S. tabernaemontani*), bur-reeds (*Sparganium americanum*, *S. angustifolium*, *S. chlorocarpum*, *S. eurycarpum*, *S. fluctuans*, and *S. minimum*), great duckweed (*Spirodela polyrhiza*), cat-tails (*Typha angustifolia* and *T. latifolia*), water-meals (*Wolffia* spp.), and wild rice (*Zizania aquatica* and *Z. palustris*).

Marshes often consist of distinct zones. Along the drier margins of the emergent marsh, grasses and sedges typically dominate. In the broad marshes along the Great Lakes shoreline, this grass-sedge-dominated zone is treated as part of the larger Great Lakes marsh. Along lakes and streams, the shallow, inner marsh protected from wave action or current is often dense, with considerable plant diversity. Closer to the open water, species diversity is reduced due to deeper water, more anaerobic conditions, and greater erosion by waves or current. Most species in the outer marsh are perennial rhizomatous plants strongly adapted to aquatic habitats.

Noteworthy Animals

Emergent marshes provide habitat to a broad diversity of aquatic invertebrates, many of which occupy and feed on decomposing vegetation. The invertebrates support numerous species of fish, amphibians (frogs), reptiles (snakes and turtles), waterfowl, water birds, and wetland mammals like muskrat (*Ondatra zibethicus*). Muskrats and beaver (*Castor canadensis*) can profoundly influence the hydrology of emergent marshes and surrounding wetlands. Muskrats create open water channels, and beavers can cause substantial flooding through their dam-building activities. Emergent marshes flood seasonally, especially in the spring, providing temporary habitat and spawning grounds for fish such as northern pike (*Esox lucius*), and many other organisms listed above.

Rare Plants

Armoracia lacustris (lakecress, state threatened)
Beckmannia syzigachne (slough grass, state threatened)
Calamagrostis stricta (narrow-leaved reedgrass, state threatened)
Callitriche hermaphroditica (autumnal water-starwort, state special concern)
Callitriche heterophylla (large water-starwort, state threatened)
Cyperus acuminatus (nut-grass, presumed extirpated from Michigan)
Eleocharis equisetoides (horsetail spike-rush, state special concern)
Eleocharis geniculata (spike-rush, presumed extirpated from Michigan)
Glyceria acutiflora (manna grass, presumed extirpated from Michigan)
Gratiola aurea (hedge-hyssop, state threatened)
Hibiscus laevis (smooth rose-mallow, presumed extirpated from Michigan)
Justicia americana (water-willow, state threatened)
Juncus militaris (bayonet rush, state threatened)
Lemna valdiviana (pale duckweed, presumed extirpated from Michigan)
Littorella uniflora (American shore-grass, state special concern)
Mimulus alatus (wing-stemmed monkey-flower, presumed extirpated from Michigan)
Myriophyllum alterniflorum (alternate-leaved water-milfoil, state special concern)
Myriophyllum farwellii (Farwell's water-milfoil, state threatened)
Nelumbo lutea (American lotus, state threatened)
Nuphar pumila (small yellow pond-lily, state endangered)
Nymphaea tetragona ssp. *leibergii* (pygmy water-lily, state endangered)
Potamogeton confervoides (alga pondweed, state special concern)
Potamogeton hillii (Hill's pondweed, state threatened)
Ranunculus ambigens (spearwort, state threatened)
Ranunculus macounii (Macoun's buttercup, state threatened)
Sabatia angularis (rose pink, state threatened)
Sagittaria montevidensis (arrowhead, state threatened)
Zizania aquatica var. *aquatica* (wild rice, state threatened)

Rare Animals

Botaurus lentiginosus (American bittern, state special concern)
Chlidonias niger (black tern, state special concern)
Emydoidea blandingii (Blanding's turtle, state special concern)
Ixobrychus exilis (least bittern, state threatened)
Pantherophis spiloides (gray ratsnake, state special concern)
Planorbella smithi (aquatic snail, endangered)
Rallus elegans (king rail, state endangered)
Siren intermedia nettingi (western lesser siren, state special concern)
Sterna forsteri (Forster's tern, state threatened)

Biodiversity Management Considerations

Eliminating off-road vehicle (ORV) traffic, nutrient and sediment inputs, dredging, ditching, and draining activity, and invasive species populations is integral to protecting the ecological integrity of high-quality emergent marsh. Dredging for marl has destroyed many marshes along the edges of small lakes in eastern Upper Michigan and in portions of Lower Michigan. Ditching and subsequent drainage allow shrubs and trees to establish and eventually replace emergent marshes. ORVs can disturb sediments and introduce seed from invasive plants like purple loosestrife (*Lythrum salicaria*) and narrow-leaved cat-tail (*Typha angustifolia*). In addition to purple loosestrife and narrow-leaved cat-tail, invasive species that threaten diversity in emergent marsh include reed (*Phragmites australis*), reed canary grass (*Phalaris arundinacea*), hybrid cat-tail (*Typha xglauca*), frogbit (*Hydrocharis morsus-ranae*), watercress (*Nasturtium officinale*), and European marsh thistle (*Cirsium palustre*). Increased nutrient input in the form of runoff from agricultural fields and lawns, leaking septic systems, and sewage discharge can result in an expansion of invasive plants such as narrow-leaved cat-tail, hybrid cat-tail, reed, and reed canary grass, and accompanying loss of native plant and animal diversity. Increased sedimentation resulting from soil disturbances upslope creates ideal conditions for colonization and expansion of reed canary grass and purple loosestrife.

Where emergent marsh borders fire-dependent upland communities, management should include prescription burning of both the marsh and adjacent uplands to facilitate seed bank expression and seedling establishment.

Variation

Emergent marshes can be dominated by a diversity of emergent plants. NatureServe and many states and regions subdivide and name their emergent marshes on the basis of dominant species (e.g., spike-rush marsh, bulrush marsh, cat-tail marsh, etc).

Similar Natural Communities

Submergent marsh, Great Lakes marsh, intermittent wetland, coastal plain marsh, southern wet meadow, and northern wet meadow.

Relevant Literature

- Albert, D.A. 2003. Between land and lake: Michigan's Great Lakes coastal wetlands. Michigan Natural Features Inventory. Michigan State University Extension, East Lansing, MI. Bulletin E-2902. 96 pp.
- Cronk, J.K., and M. Siobhan Fennessy. 2001. Wetland plants: Biology and ecology. Lewis Publishers, Boca Raton, FL. 462 pp.

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- Hutchinson, G.E. 1975. A treatise on limnology. Volume 3. Limnological botany. John Wiley and Sons, New York, NY. 660 pp.

Great Lakes Marsh

Global/State Rank: G2/S3

Overview

Great Lakes marsh is an herbaceous wetland community occurring statewide along the shoreline of the Great Lakes and their major connecting rivers. Vegetational patterns are strongly influenced by water level fluctuations and type of coastal feature, but generally include the following: a deep marsh with submerged plants; an emergent marsh of mostly narrow-leaved species; and a sedge-dominated wet meadow that is inundated by storms. Great Lakes marsh provides important habitat for migrating and breeding waterfowl, shore-birds, spawning fish, and medium-sized mammals.

Landscape Context

Great Lakes marshes occur along all of the Great Lakes and their connecting rivers, including the Detroit, St. Clair, and St. Mary's Rivers. The physical and chemical characteristics of different surficial bedrock types affect wetland location and species composition. Igneous and metamorphic bedrocks form the shore of Lake Superior. Softer, sedimentary bedrock types underlie Lakes Michigan, Huron, St. Clair, Erie, and Ontario, as well as the large connecting rivers. Along Lake Superior, marshes occur only behind protective barrier beaches or at stream mouths. In contrast, the horizontally deposited marine and nearshore sedimentary rocks underlying Lakes Michigan, Huron, St. Clair, Erie, and Ontario provide broad zones of shallow water and fine-textured substrates for marsh development.

Great Lakes marshes occur in all three aquatic systems, including lacustrine, connecting channel, and riverine wetlands, which are defined by water flow characteristics and residence time. *Lacustrine* wetlands refers to open bays, protected bays, and barrier-protected wetlands. Barrier-protected wetlands are separated from the Great Lakes by porous sand or gravel barriers, allowing water level and chemical influence from the lake, but protection from storm erosion. *Connecting channels* refers to the major rivers linking the Great Lakes, including the St. Mary's, Detroit, and St. Clair Rivers, all characterized by a large flow, but seasonally stable hydrology. *Riverine* aquatic system refers to smaller rivers tributary to the Great Lakes whose water quality, flow rate, and sediment load are controlled in large part by their individual drainages, but with Great Lakes influence near their mouth, where large wetlands are located.

Soils

Where bedrock is at or near the surface, bedrock chemistry affects wetland species composition. Soils derived from Precambrian crystalline bedrock along Lake Superior are generally acid and favor the development of poor fen or bog communities. In contrast, soils derived from marine deposits in the lower Great Lakes, including shale and marine limestone, dolomite, and evaporites, are typically more calcareous (less acid), creating the preferred habitat for calciphilic aquatic plant species and development of more minerotrophic communities such as wet meadow and coastal fen.

Natural Processes

Water level fluctuations greatly influence vegetation patterning. Fluctuations occur over three temporal scales: short-term fluctuations (seiche) in water level caused by persistent winds and/or differences in barometric pressure; seasonal fluctuations reflecting the annual hydrologic cycle in the Great Lakes basin; and interannual fluctuations in lake level as a result of variable

precipitation and evaporation within their drainage basins. Interannual fluctuations of 3.5 to 6.5 feet (1.3 to 2.5 m) result in changes in water current, wave action, turbidity, nutrient content or availability, alkalinity, and temperature. Coastal wetland systems are adapted to and require periodic inundation. Seiches, storms, and water level cycles strikingly change vegetation over short periods by destroying some vegetation zones, creating others, and forcing all zones to shift lakeward or landward to accommodate water levels. Coastal wetlands are also affected by longshore currents and storm waves. Wind and wave action and ice scour are the primary agents responsible for shoreline erosion and redeposition of sediments in marshes.

Vegetation

There are three distinct zones within most Great Lakes marshes: wet meadow, emergent marsh, and submergent marsh. The wet meadow zone typically has shallow, saturated organic soils, but in some years it can be flooded throughout the growing season. Grasses and sedges typically dominate the wet meadow zone, along with numerous other herbaceous genera. During dry periods, shrubs and tree seedlings commonly establish. The emergent marsh zone is permanently flooded with shallow water throughout the growing season in most years, but can be dry when Great Lakes water levels are low. Dominant plants in the emergent marsh zone include bulrushes (*Scirpus* spp. and *Schoenoplectus* spp.), spike-rushes (*Eleocharis* spp.), rushes (*Juncus* spp.), and cat-tails (*Typha* spp.), in addition to submergent and floating plants. The submergent zone has deep water and few or no emergent species. Dominant plants in the submergent marsh zone include numerous floating or submergent species.

Based on vegetation sampling of 102 Great Lakes marshes, only one plant was considered common (i.e., present in 80% or more of the marshes): bluejoint grass (*Calamagrostis canadensis*), which occurs in the wet meadow zone. Additional plants of the wet meadow zone include marsh bell flower (*Campanula aparinoides*), sedges (*Carex aquatilis*, *C. lacustris*, and *C. stricta*), water hemlock (*Cicuta bulbifera*), jewelweed (*Impatiens capensis*), small bedstraw (*Galium trifidum*), water smartweed (*Polygonum amphibium*), marsh cinquefoil (*Potentilla palustris*), common skullcap (*Scutellaria galericulata*), broad-leaved cat-tail (*Typha latifolia*), and the invasive species, narrow-leaved cat-tail (*T. angustifolia*). Plants of the emergent zone include hardstem bulrush (*Schoenoplectus acutus*), three-square (*Schoenoplectus pungens*), spike-rush (*Eleocharis smallii*), common arrowhead (*Sagittaria latifolia*), and several other submergent and floating species. Plants of the submergent marsh and open flooded portions of the emergent zone include pondweed (*Potamogeton natans*), water-celery (*Vallisneria americana*), common waterweed (*Elodea canadensis*), bladderwort (*Utricularia vulgaris*), coontail (*Ceratophyllum demersum*), slender naiad (*Najas flexilis*), and sweet-scented water-lily (*Nymphaea odorata*).

Noteworthy Animals

Great Lakes coastal wetlands provide important habitat for insects, fish, waterfowl, water birds, and mammals. Over 50 species of fish, including several game fish, have been documented to utilize the coastal wetlands of northern Lake Huron. Fish utilize coastal wetlands in all parts of their life cycle, including egg, larval, immature, and adult stages. A broad range of invertebrates occupy this habitat, providing food for fish, birds, herptiles, and small mammals. Coastal wetlands have long been recognized as critical habitat for the migration, feeding, and nesting of waterfowl and shorebirds. The Great Lakes and connecting rivers are parts of several major flyways. During spring migration, when few alternative sources of nutrients are available, terrestrial migratory songbirds feed on midges from the Great Lakes marshes. Mammals utilizing coastal wetlands include beaver (*Castor canadensis*), muskrat (*Ondatra zibethicus*), river otter (*Lutra canadensis*), and mink (*Mustela vison*).

Rare Plants

Hibiscus laevis (smooth rose-mallow, presumed extirpated from Michigan)

Nelumbo lutea (American lotus, state threatened)

Sagittaria montevidensis (arrowhead, state threatened)

Zizania aquatica var. *aquatica* (wild rice, state threatened)

Rare Animals

Botaurus lentiginosus (American bittern, state special concern)

Chlidonias niger (black tern, state special concern)

Circus cyaneus (northern harrier, state special concern)

Cistothorus palustris (marsh wren, state special concern)

Emydoidea blandingii (Blanding's turtle, state special concern)

Falco columbarius (merlin, state threatened)

Ixobrychus exilis (least bittern, state threatened)

Nycticorax nycticorax (black-crowned night-heron, state special concern)

Pantherophis gloydi (eastern fox snake, state threatened)

Rallus elegans (king rail, state endangered)

Somatochlora hineana (Hine's emerald, federal/state endangered)

Sterna forsteri (Forster's tern, state threatened)

Xanthocephalus xanthocephalus (yellow-headed blackbird, state special concern)

Biodiversity Management Considerations

Water-level control has altered natural wetland dynamics. All the connecting channels have been modified to accommodate shipping, resulting in increased shoreline erosion. Agricultural drainage has eliminated large areas of marshes, and agricultural sedimentation has greatly increased turbidity, eliminating submergent species that require clear water. The resulting deposition of rich organic sediments in the wet meadow zone and along the shoreline favors early-successional species. Nutrient loading has locally reduced oxygen levels, prompted algal blooms, and led to the dominance of high-nutrient tolerant species such as cat-tails.

Urban development degrades and eliminates coastal marshes through pollution, land management, and ecosystem alteration. Armoring shoreline and dredging of harbors eliminate marshes. Dumping of waste materials such as sawdust, sewage, and chemicals alters shallow-water marsh environments, increasing turbidity, reducing oxygen levels, and altering the pH. Shipping traffic erodes shoreline vegetation through excessive wave action. Introductions of invasive plants and animals have altered community structure and species composition. Many invasive species arrive in shipping ballast, while others are purposefully introduced. Some of the invasive plants that threaten the diversity and community structure of Great Lakes marsh include reed (*Phragmites australis*), narrow-leaved cat-tail (*Typha angustifolia*), hybrid cat-tail (*Typha x glauca*), reed canary grass (*Phalaris arundinacea*), purple loosestrife (*Lythrum salicaria*), frogbit (*Hydrocharis morsus-ranae*), hydrilla (*Hydrilla verticillata*), watercress (*Nasturtium officinale*), and European marsh thistle (*Cirsium palustre*).

Maintaining hydrologic regimes, in addition to eliminating off-road vehicle (ORV) traffic, nutrient and sediment inputs, and invasive species populations, is integral to protecting the ecological integrity of high-quality Great Lakes marshes.

Variation

There are several regionally distinctive marsh types due to regional differences in geomorphology, water chemistry, and land use. These types include Lake Superior's poor fens,

rich fens in the Straits of Mackinac, lacustrine estuaries or buried river mouth on Lake Michigan, Saginaw Bay lakeplain marshes, and Lake Erie–Lake St. Clair lakeplain marshes.

Similar Natural Communities

Submergent marsh, emergent marsh, northern wet meadow, southern wet meadow, interdunal wetland, poor fen, coastal fen, northern fen, lakeplain wet prairie, lakeplain wet-mesic prairie, northern shrub thicket, southern shrub-carr, and wooded dune and swale complex.

Relevant Literature

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- Minc, L.D. 1997. Great Lakes coastal wetlands: An overview of abiotic factors affecting their distribution, form, and species composition. A report in three parts. Michigan Natural Features Inventory, Lansing, MI. 307 pp.

For a full list of references used to create this description, please refer to the natural community abstract for Great Lakes marsh.

Northern Wet Meadow

Global/State Rank: G4G5/S4

Overview

Northern wet meadow is an open, groundwater-influenced, sedge- and grass-dominated wetland that occurs in the northern Lower and Upper Peninsulas and typically borders streams but is also found on pond and lake margins and above beaver dams. Soils are nearly always sapric peat and range from strongly acid to neutral in pH. Open conditions are maintained by seasonal flooding, beaver-induced flooding, and fire.

Landscape Context

Northern wet meadow occurs on glacial lakebeds, in channels of glacial outwash, and in depressions on glacial outwash and moraines. The community frequently occurs along the margins of lakes, ponds, and streams where seasonal flooding or beaver-induced flooding is common. Northern wet meadow is regularly found adjacent to other wetland communities, often in large wetland complexes. Along streams, northern wet meadow typically borders northern shrub thicket and swamp forest. On the edges of inland lakes, northern wet meadow often borders emergent marsh and less frequently northern fen. It may also occur along the Great Lakes shoreline within extensive areas of Great Lakes marsh.

Soils

Northern wet meadow typically occurs on organic soils such as well-decomposed sapric peat, but saturated mineral soil may also support the community. Soil pH typically ranges from strongly acid to neutral. Northern wet meadow occurs on more acidic soils compared to southern wet meadow, which is found on neutral to strongly alkaline soils.

Natural Processes

Northern wet meadows are strongly influenced by groundwater with water levels fluctuating seasonally, reaching their peaks in spring and lows in late summer. Water levels typically remain at or near the soil surface throughout the year. Beaver-induced flooding may also play an important role in maintaining the community by occasionally raising water levels and killing encroaching trees and shrubs. Beaver can also help create new northern wet meadows by flooding swamp forests and northern shrub thickets and thus creating suitable habitat for the growth of shade-intolerant wet meadow species. Fire is also an important natural disturbance within these systems. By reducing leaf litter and allowing light to reach the soil surface and stimulate seed germination, fire can play an important role in maintaining wet meadow seed banks and species diversity. Fire helps prevent declines in species richness in many community types by temporarily reducing competition from robust perennials and creating micro-niches for small species. In the absence of fire, a thick layer of leaf litter can develop that stifles seed germination and seedling establishment. Another critically important attribute of fire for maintaining open sedge meadow is its ability to temporarily reduce shrub cover. In the absence of fire or flooding, all but the wettest sedge meadows typically convert to shrub thicket and eventually swamp forest.

Vegetation

Northern wet meadow is a sedge-dominated wetland that typically has 100% vegetative cover in the ground layer and is often dominated by tussock sedge (*Carex stricta*). Other characteristic sedges include lake sedge (*C. lacustris*), wiregrass sedge (*C. lasiocarpa*), beaked sedge (*C. rostrata*), and blister sedge (*C. vesicaria*). The most dominant grass species is bluejoint grass

(*Calamagrostis canadensis*). Other common grasses include fringed brome (*Bromus ciliatus*), rattlesnake grass (*Glyceria canadensis*), fowl manna grass (*G. striata*), marsh wild-timothy (*Muhlenbergia glomerata*), leafy satin grass (*M. mexicana*), and fowl meadow grass (*Poa palustris*). Bald spike-rush (*Eleocharis erythropoda*), broad-leaved cat-tail (*Typha latifolia*), twig-rush (*Cladium mariscoides*), and green bulrush (*Scirpus atrovirens*) are also common graminoids. A wide variety of wetland forbs occur in northern wet meadow. The following are some of the more common species: Canada anemone (*Anemone canadensis*), swamp milkweed (*Asclepias incarnata*), eastern lined aster (*Aster lanceolatus*), side-flowering aster (*A. lateriflorus*), swamp aster (*A. puniceus*), flat-topped white aster (*A. umbellatus*), marsh bellflower (*Campanula aparinoides*), water-hemlocks (*Cicuta bulbifera* and *C. maculata*), swamp thistle (*Cirsium muticum*), downy willowherb (*Epilobium strictum*), joe-pye-weed (*Eupatorium maculatum*), common boneset (*E. perfoliatum*), grass-leaved goldenrod (*Euthamia graminifolia*), rough bedstraw (*Galium asprellum*), small bedstraw (*G. trifidum*), jewelweed (*Impatiens capensis*), wild blue flag (*Iris versicolor*), marsh pea (*Lathyrus palustris*), common water horehound (*Lycopus americanus*), northern bugleweed (*L. uniflorus*), tufted loosestrife (*Lysimachia thyrsiflora*), wild mint (*Mentha arvensis*), marsh cinquefoil (*Potentilla palustris*), water smartweed (*Polygonum amphibium*), great water dock (*Rumex orbiculatus*), common arrowhead (*Sagittaria latifolia*), common skullcap (*Scutellaria galericulata*), Canada goldenrod (*Solidago canadensis*), late goldenrod (*S. gigantea*), swamp goldenrod (*S. patula*), purple meadow rue (*Thalictrum dasycarpum*), marsh St. John's-wort (*Triadenum fraseri*), blue vervain (*Verbena hastata*), and marsh violet (*Viola cucullata*). Characteristic fern or fern allies include crested woodfern (*Dryopteris cristata*), common horsetail (*Equisetum arvense*), water horsetail (*E. fluviatile*), sensitive fern (*Onoclea sensibilis*), and marsh fern (*Thelypteris palustris*). Scattered shrub and tree species include tag alder (*Alnus rugosa*), bog birch (*Betula pumila*), red-osier dogwood (*Cornus stolonifera*), shrubby cinquefoil (*Potentilla fruticosa*), willows (*Salix* spp.), meadowsweet (*Spiraea alba*), steeplebush (*S. tomentosa*), red maple (*Acer rubrum*), black ash (*Fraxinus nigra*), tamarack (*Larix laricina*), balsam poplar (*Populus balsamifera*), quaking aspen (*Populus tremuloides*), and northern white-cedar (*Thuja occidentalis*).

Noteworthy Animals

The late-blooming composites found in sedge meadows provide an important food source for insects, which in turn support songbirds. The hummock-hollow microtopography provides excellent nesting habitat for wetland birds. Beavers (*Castor canadensis*) can cause substantial flooding through their dam-building activities.

Rare Plants

Cacalia plantaginea (prairie Indian-plantain, state special concern)
Carex wiegandii (Wiegand's sedge, state special concern)
Gentiana linearis (linear-leaved gentian, state threatened)
Parnassia palustris (marsh-grass-of-Parnassus, state threatened)
Petasites sagittatus (sweet coltsfoot, state threatened)
Silene nivea (evening campion, state endangered)
Vaccinium cespitosum (dwarf bilberry, state threatened)

Rare Animals

Alces americanus (moose, state special concern)
Asio flammeus (short-eared owl, state endangered)
Botaurus lentiginosus (American bittern, state special concern)
Canis lupus (gray wolf, federal endangered and state threatened)
Chlidonias niger (black tern, state special concern)
Circus cyaneus (northern harrier, state special concern)

Cistothorus palustris (marsh wren, state special concern)
Clemmys guttata (spotted turtle, state threatened)
Coturnicops noveboracensis (yellow rail, state threatened)
Emydoidea blandingii (Blanding's turtle, state special concern)
Gallinula chloropus (common moorhen, state threatened)
Glyptemys insculpta (wood turtle, state special concern)
Ixobrychus exilis (least bittern, state threatened)
Lycaeides idas nabokovi (northern blue butterfly, state threatened)
Lynx canadensis (lynx, state endangered)
Phalaropus tricolor (Wilson's phalarope, state special concern)
Pseudacris maculata (boreal chorus frog, state special concern)
Rallus elegans (king rail, state endangered)
Sistrurus c. catenatus (eastern massasauga, federal candidate species and state special concern)
Sterna forsteri (Forster's tern, state threatened)

Biodiversity Management Considerations

Northern wet meadows contribute significantly to the overall biodiversity of northern Michigan and also provide ecosystem services, protecting water quality by assimilating nutrients, trapping sediment, and retaining storm and floodwaters. Protecting the hydrology of northern wet meadow is imperative for the community's continued existence and includes avoiding surface water inputs to meadows from drainage ditches, agricultural fields, road construction, and logging in the adjacent uplands, and protecting groundwater recharge areas by maintaining native vegetation types in the uplands surrounding the community. In forested landscapes, establishing no-cut buffers around wet meadows and avoiding road construction and complete canopy removal in stands immediately adjacent to wetlands can help protect the hydrologic regime.

In fire-prone landscapes, management for wet meadow should include the use of prescribed fire. Prescribed fire can help reduce litter and woody cover, stimulate seed germination, promote seedling establishment, and bolster grass, sedge, and perennial and annual forb cover. If prescribed burning is not feasible, mowing can be used to reduce woody plant cover but should be restricted to the winter, when ground frost will reduce disturbance to soils, herbaceous plants, and hydrology, or late summer and fall when meadows are dry. Because most wetland shrubs are capable of resprouting when cut (or burned), the application of herbicides to recently cut stumps may be required to maintain open conditions.

Management should strive to prevent the establishment and spread of invasive species. Invasive species that pose a threat to the diversity and community structure of northern wet meadow include glossy buckthorn (*Rhamnus frangula*), purple loosestrife (*Lythrum salicaria*), narrow-leaved cat-tail (*Typha angustifolia*), hybrid cat-tail (*Typha xglauca*), reed (*Phragmites australis*), reed canary grass (*Phalaris arundinacea*), common buckthorn (*Rhamnus cathartica*), and multiflora rose (*Rosa multiflora*). Establishment of invasive species can be prevented by maintaining the hydrologic and fire disturbance regimes and avoiding grazing. Because of the difficulty of restoring wet meadow in the absence of favorable hydrology and intact organic soils, conservation efforts should focus on protecting and managing the remaining community occurrences.

Northern wet meadows have been extensively utilized for agriculture. Prior to the 1950s, mowing for marsh hay was widely practiced. Wet meadows were frequently tilled, ditched, drained, and converted to pasture and row crops or mined for peat. The hydrology of these systems is threatened by agricultural runoff and nutrient enrichment, stream channelization, and reductions in local water tables as a result of excessive groundwater withdrawals and ditching. Lowering of

the water table has caused the conversion of many sedge meadows to shrub thickets. In addition, fire suppression has allowed shrub encroachment with many sedge meadows converting to shrub thicket within ten to twenty years. Shrub encroachment is especially evident where the practice of mowing for marsh hay has been abandoned. In addition to shrub encroachment, alteration of the fire and hydrologic regimes has allowed for the invasion of sedge meadows by pernicious non-native species, especially purple loosestrife, reed canary grass, and glossy buckthorn. Sedge meadows disturbed by agricultural use, grazing, drainage, and/or filling are frequently dominated by reed canary grass, an extremely aggressive grass that forms persistent, monotypic stands.

Variation

Community structure and plant diversity can vary significantly among northern wet meadows depending on the dominant species of sedge. Wet meadows dominated by tussock sedge have complex microtopography, which fosters high levels of forb diversity. Wet meadows dominated by lake sedge typically have little microtopographic complexity and low forb diversity.

Similar Natural Communities

Emergent marsh, Great Lakes marsh, intermittent wetland, southern wet meadow, northern fen, northern shrub thicket, wet-mesic sand prairie, poor fen, and wet prairie.

Relevant Literature

- Cohen, J.G., and M.A. Kost. 2007. Natural community abstract for northern wet meadow. Michigan Natural Features Inventory, Lansing, MI. 9 pp.
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- Reuter, D.D. 1986. Sedge meadows of the upper Midwest: A stewardship summary. *Natural Areas Journal* 6(4): 27-34.
- Warners, D.P. 1997. Plant diversity in sedge meadows: Effects of groundwater and fire. Ph.D. dissertation, University of Michigan, Ann Arbor, MI. 231 pp.

For a full list of references used to create this description, please refer to the natural community abstract for northern wet meadow.

Southern Wet Meadow

Global/State Rank: G4?/S3

Overview

Southern wet meadow is an open, groundwater-influenced (minerotrophic), sedge-dominated wetland that occurs in central and southern Lower Michigan. Open conditions are maintained by seasonal flooding, beaver-induced flooding, and fire. Sedges in the genus *Carex*, in particular tussock sedge (*Carex stricta*), dominate the community. Southern wet meadow, commonly referred to as sedge meadow, also occurs in Iowa, Illinois, Indiana, Minnesota, North Dakota, Wisconsin, and Ontario.

Landscape Context

Southern wet meadow occurs on glacial lakebeds, lakeplains, and in depressions on glacial outwash and moraines. The community frequently occurs along the margins of lakes and streams, where seasonal flooding or beaver-induced flooding is common.

Soils

Southern wet meadow typically occurs on neutral to strongly alkaline organic soils (i.e., sapric to hemic peat), but saturated mineral soil may also support the community. Because of the calcareous nature of the glacial drift in the regions where southern wet meadow occurs, its soils typically contain high levels of calcium and magnesium.

Natural Processes

Water levels in southern wet meadow may fluctuate seasonally, reaching their peak in spring and lows in late summer, but typically remain at or near the soil's surface throughout the year. The structure of southern wet meadow is largely influenced by tussock sedge, which forms large tussocks up to 0.5 m high on which many additional species successfully establish above the zone of seasonal inundation. Community structure may depend on a consistently high water table as the tussocks of *Carex stricta* rapidly decompose when water levels are reduced by tiling. In addition to seasonal flooding, beaver-induced flooding also maintains open conditions by killing encroaching trees and shrubs.

Southern wet meadow is a fire-dependent natural community. By reducing leaf litter and allowing light to reach the soil surface and stimulate seed germination, fire can play an important role in maintaining southern wet meadow seed banks. Fire plays a critical role in maintaining species richness by creating open microsites for small species. Another critically important attribute of fire is its ability to temporarily reduce shrub and tree cover.

In the absence of fire or beaver-induced flooding, all but the wettest sedge meadows typically convert to shrub-carr and eventually swamp forest. Prolonged flooding may also create new southern wet meadows by killing trees and shrubs of swamp forests and shrub-carrs, thus allowing shade-intolerant wet meadow species such as tussock sedge to become established.

Vegetation

Southern wet meadow is typically dominated by tussock sedge. Because its roots form large hummocks or tussocks, the species is responsible for the community's hummock and hollow structure. As the shaded areas between tussocks are often covered with standing water and leaf litter, many of the shorter species inhabiting sedge meadows grow almost exclusively from the

sides or tops of *Carex stricta* tussocks. Additional common sedges include *Carex aquatilis*, *C. comosa*, *C. bebbii*, *C. hystericina*, *C. lacustris*, *C. pellita*, *C. lasiocarpa*, *C. prairea*, *C. rostrata*, *C. sartwellii*, *C. stipata*, and *C. vulpinoidea*. The most dominant grass species in southern wet meadow is bluejoint grass (*Calamagrostis canadensis*), sometimes occurring as a codominant with tussock sedge. Other common grasses include fringed brome (*Bromus ciliatus*), fowl manna grass (*Glyceria striata*), marsh wild-timothy (*Muhlenbergia glomerata*), leafy satin grass (*M. mexicana*), and fowl meadow grass (*Poa palustris*). A wide variety of wetland forbs and several ferns occur in southern wet meadow, including swamp milkweed (*Asclepias incarnata*), swamp aster (*Aster puniceus*), smooth swamp aster (*A. firmus*), marsh bellflower (*Campanula aparinoides*), water hemlock (*Cicuta bulbifera*), swamp thistle (*Cirsium muticum*), joe-pye-weed (*Eupatorium maculatum*), common boneset (*E. perfoliatum*), rough bedstraw (*Galium asprellum*), marsh pea (*Lathyrus palustris*), northern bugle weed (*Lycopus uniflorus*), tufted loosestrife (*Lysimachia thyrsoiflora*), clearweed (*Pilea pumila*), water smartweed (*Polygonum amphibium*), Virginia mountain mint (*Pycnanthemum virginianum*), great water dock (*Rumex orbiculatus*), common arrowhead (*Sagittaria latifolia*), common skullcap (*Scutellaria galericulata*), Canada goldenrod (*Solidago canadensis*), late goldenrod (*S. gigantea*), swamp goldenrod (*S. patula*), purple meadow rue (*Thalictrum dasycarpum*), marsh St. John's-wort (*Triadenum fraseri*), marsh fern (*Thelypteris palustris*), and sensitive fern (*Onoclea sensibilis*).

Noteworthy Animals

Muskrat (*Ondatra zibethicus*) commonly build lodges in southern wet meadows, which when abandoned are used by Canada geese (*Branta canadensis*) as nesting sites. Sandhill cranes (*Grus canadensis*) and marsh wrens (*Cistothorus palustris*, state special concern) also use the community for nesting habitat. Beaver (*Castor canadensis*) help maintain open conditions through dam building and subsequent flooding and also through herbivory of shrubs and trees.

Rare Plants

Gentianella quinquefolia (stiff gentian, state threatened)
Mimulus alatus (wing-stemmed monkey flower, presumed extirpated from Michigan)
Pycnanthemum muticum (broad-leaved mountain mint, state threatened)

Rare Animals

Acris blanchardi (Blanchard's cricket frog, state threatened)
Ambystoma texanum (smallmouth salamander, state endangered)
Asio flammeus (short-eared owl, state endangered)
Botaurus lentiginosus (American bittern, state special concern)
Calephelis mutica (swamp metalmark, state special concern)
Circus cyaneus (northern harrier, state threatened)
Cistothorus palustris (marsh wren, state special concern)
Clonophis kirtlandii (Kirtland's snake, state endangered)
Emydoidea blandingii (Blanding's turtle, state special concern)
Euphyes dukesi (Dukes' skipper, state threatened)
Meropleon ambifusca (Newman's brocade, state special concern)
Neoconocephalus lyrists (bog conehead, state special concern)
Neoconocephalus retusus (conehead grasshopper, state special concern)
Neonympha m. mitchellii (Mitchell's satyr, federal/state threatened)
Nerodia erythrogaster neglecta (copperbelly watersnake, federal threatened and state endangered)
Oarisma poweshiek (Poweshiek skipperling, state threatened)
Orchelimum concinnum (red-faced meadow katydid, state special concern)
Orchelimum delicatum (delicate meadow katydid, state special concern)

Papaipema cerina (golden borer, state special concern)
Papaipema maritima (maritime sunflower borer, state special concern)
Papaipema speciosissima (regal fern borer, state special concern)
Paroxya hoosieri (Hoosier locust, state special concern)
Phalaropus tricolor (Wilson's phalarope, state special concern)
Rallus elegans (king rail, state endangered)
Sistrurus c. catenatus (eastern massasauga, federal candidate species and state special concern)
Spartiniphaga inops (spartina moth, state special concern)
Speyeria idalia (regal fritillary, state endangered)

Biodiversity Management Considerations

Because restoration of degraded southern wet meadows can be difficult in the absence of favorable hydrology, intact organic soils, and a viable seed source for *Carex stricta*, conservation efforts should focus on protecting and managing existing southern wet meadows. Maintaining the natural hydrology of southern wet meadow is imperative for the community's continued existence. This may include avoiding surface water inputs to the meadow from drainage ditches and agricultural fields, and protecting groundwater recharge areas by maintaining native vegetation types in the uplands around the community. Management for southern wet meadows should include the use of prescribed fire to help reduce litter, stimulate seed germination, promote seedling establishment and plant growth, limit shrub and tree encroachment, and control invasive species. Ideally, prescribed fire management of southern wet meadows would be orchestrated with that of surrounding fire-dependent wetland and upland communities. If prescribed burning is not feasible, mowing can be used to reduce woody plant cover but should be restricted to the winter, when ground frost will reduce disturbance to soils, herbaceous plants, and hydrology, or late summer and fall when meadows are dry. Because most wetland shrubs are capable of resprouting when cut (or burned), the application of herbicides to recently cut stumps may be required to maintain open conditions.

Monitoring and control efforts to detect and remove invasive species are critical to the long-term viability of southern wet meadow. Invasive species that threaten the diversity and community structure include purple loosestrife (*Lythrum salicaria*), reed canary grass (*Phalaris arundinacea*), reed (*Phragmites australis*), narrow-leaved cat-tail (*Typha angustifolia*), hybrid cat-tail (*Typha xglauca*), glossy buckthorn (*Rhamnus frangula*), and multiflora rose (*Rosa multiflora*).

Variation

Community structure and plant diversity can vary significantly among southern wet meadows depending on the dominant species of sedge. Wet meadows dominated by tussock sedge have complex microtopography, which fosters high levels of forb diversity. Wet meadows dominated by lake sedge typically have little microtopographic complexity and low forb diversity.

Similar Natural Communities

Emergent marsh, northern wet meadow, poor fen, prairie fen, wet prairie, lakeplain wet prairie, Great Lakes marsh, and southern shrub-carr.

Relevant Literature

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- Warners, D.P. 1993. Species diversity in southern Michigan sedge meadows: Unpublished report to The Nature Conservancy, Michigan Chapter, East Lansing, MI. 35 pp.
- Warners, D.P. 1997. Plant diversity in sedge meadows: Effects of groundwater and fire. Ph.D. dissertation, University of Michigan, Ann Arbor, MI. 231 pp.

For a full list of references used to create this description, please refer to the natural community abstract for southern wet meadow.

Inland Salt Marsh

Global/State Rank: G1/S1

Overview

Inland salt marsh is an herbaceous wetland occurring on mineral soil saturated by sodium- and chloride-laden groundwater from natural brine aquifers. In Michigan, salt marshes and seeps were concentrated in areas where Silurian or Devonian halites (rock salt deposits) occur near the surface. The only known, intact salt marshes in Michigan today occur along the Maple River in northern Clinton County. Historically, salt marshes were known from elsewhere in Michigan as well as Illinois, Missouri, New York, Ohio, Pennsylvania, and Virginia, but today the community persists only in Illinois, Michigan, and New York.

Landscape Context

Inland salt marshes are most common along streams or rivers, where glacial drift is thin enough to permit brine from deep saline aquifers to remain concentrated and emerge at discrete points.

Soils

This community occurs on peat, muck, or mineral soils saturated by sodium- or chlorine-rich groundwater seeping from saline aquifers. Soils of an intact salt marsh in Michigan were found to be high in sodium, chloride, potassium, calcium, and magnesium and have a pH that ranged from medium acid to moderately alkaline.

Natural Processes

Inland salt marshes often have open, unvegetated seeps and soil patches, where conditions are too extreme for plants to grow. Animals seeking salt create localized disturbances resulting in trampled, unvegetated zones within the wetland. Seasonal and annual fluctuations in the amount of seepage in salt marshes influence species composition, distribution, and establishment. Historically, fire may have also played a role in maintaining the open conditions required by most plant species found in salt marshes.

Vegetation

The extreme saline conditions of inland salt marshes regulate the vegetative composition and structure of the community. A limited number of vascular plant species can tolerate the high salt levels and wetland soils. Characteristic plants of inland salt marsh include water plantain (*Alisma plantago-aquatica*), spearscale (*Atriplex patula*), dwarf spike-rush (*Eleocharis parvula*, state endangered), bald spike-rush (*Eleocharis erythropoda*), reed (*Phragmites australis*), purslane (*Portulaca oleracea*), water-pimpernel (*Samolus floribundas*), three-square bulrush (*Schoenoplectus americanus*, state endangered), and water parsnip (*Sium suave*).

Noteworthy Animals

White-tailed deer (*Odocoileus virginianus*) tracks are abundant around inland salt marsh occurrences, and the species may be helping to maintain open conditions. Waterfowl may play a role in the introduction and dispersal of halophytes and other wetland plants.

Rare Plants

Eleocharis parvula (dwarf spike-rush, state endangered)

Schoenoplectus americanus (three-square bulrush, state endangered)

Rare Animals

Emydoidea blandingii (Blanding's turtle, state special concern)

Biodiversity Management Considerations

As salt was an important food preservative during European settlement of the Midwest, most salt marshes and seeps were heavily exploited. Conservation efforts should focus on protecting, managing, and researching existing inland salt marshes. Protection of inland salt marshes will require preserving the hydrologic integrity of the surrounding watershed. Further research on the role of fire in inland salt marshes is needed, as are detailed invertebrate and herptile surveys.

Variation

Species composition and community size likely varied regionally.

Similar Natural Communities

Emergent marsh and southern wet meadow.

Relevant Literature

- Albert, D.A. 2001. Natural community abstract for inland salt marsh. Michigan Natural Features Inventory, Lansing, MI. 3 pp.
- Allen, R.C. 1918. Mineral resources of Michigan for 1917 and prior years. Mich. Geol. and Biol. Survey Publ. 27, Geo. Series 22. 204 pp.
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- Gere, M.A. 1979. Michigan mineral producers, 1978. Geology Division, Michigan DNR, Lansing, MI. pp. 25-27, 32-33.

For a full list of references used to create this description, please refer to the natural community abstract for inland salt marsh.

Intermittent Wetland

Global/State Rank: G3/S3

Overview

Intermittent wetland is a graminoid- and herb-dominated wetland found along lakeshores or in depressions and characterized by fluctuating water levels, both seasonally and from year to year. Intermittent wetlands exhibit traits of both peatlands and marshes, with characteristic vegetation including sedges (*Carex* spp.), rushes (*Juncus* spp.), sphagnum mosses, and ericaceous shrubs. The community occurs statewide.

Landscape Context

Intermittent wetlands occur throughout Michigan on poorly drained flat areas or mild depressions of sandy glacial outwash and sandy glacial lakeplain and in kettle depressions on pitted outwash. The community is found in isolated depressions and along the shores of softwater, seepage lakes and ponds where water levels fluctuate both seasonally and yearly. Intermittent wetland may be bordered by several other wetland communities and may encircle floating bog mats. The sandy, well-drained uplands surrounding intermittent wetlands typically support fire-dependent pine and oak communities.

Soils

The sandy soils underlying intermittent wetlands are strongly to very strongly acidic and are primarily sands or occasionally loamy sands. Shallow organic deposits of peat or sandy peat may overlay the sandy substrate and in some basins, a clay layer may occur below the surface.

Natural Processes

Water level fluctuations occur both seasonally and yearly within intermittent wetlands. Seasonally, water levels tend to be highest during the winter and spring and lowest in late summer and fall. The yearly oscillations are less predictable. Fluctuations of water level within intermittent wetlands allow for temporal variability of the accumulation and decomposition of organic matter. Stable periods of saturated and inundated conditions inhibit organic matter decomposition and allow for the accumulation of peat. Dam-building activities of beaver can result in blocked drainage and flooding, which facilitate sphagnum peat development and expansion. High decomposition rates within intermittent wetlands are correlated with periods of water level fluctuation, which promote oxidation and the loss of organic material that would otherwise form peat.

Water level fluctuation in intermittent wetlands facilitates seed germination and seed dispersal, and reduces competition from woody plants. Seasonal drawdowns are critical to the survival of many intermittent wetland species, especially annuals, which readily germinate from the exposed, saturated soils. Seasonal water level fluctuation also acts as an important mechanism for seed dispersal. During the winter and spring when water levels rise, seeds deposited along the low-water line float to the surface and are carried by wave action to the wetland's outer margin. In addition, high water levels can limit tree and shrub encroachment into intermittent wetlands since prolonged flooding can result in tree and shrub mortality.

Fire is also an important component of the natural disturbance regime of intermittent wetlands. Intermittent wetlands typically occur as small depressions within a fire-dependent landscape and would have likely experienced surface fires along with the surrounding uplands when conditions

were favorable. Surface fire can contribute to the maintenance of open conditions by killing encroaching trees and shrubs. In the absence of fire, a thick layer of leaf litter can develop that stifles seed germination and seedling establishment. Fire severity and frequency in intermittent wetlands is closely related to fluctuations in water level and landscape context. Prolonged periods of lowered water table can allow the vegetation and surface peat to dry out sufficiently to burn. When the surface peat of intermittent wetlands burns, the fire mineralizes the peat, and kills seeds and latent buds of some species while stimulating seed germination and stem sprouting of others. Peat fires likely convert bogs to more graminoid-dominated wetlands such as intermittent wetlands, poor fens, and northern wet meadow. Because fire has been shown to increase seed germination, enhance seedling establishment, and bolster flowering, fire likely acts as an important mechanism for maintaining plant species diversity and replenishing the seed banks of intermittent wetlands.

Vegetation

Intermittent wetland is a sedge- and herb-dominated wetland. In many locations, the community borders or encompasses a bog mat that supports sphagnum mosses, low ericaceous, evergreen shrubs, and widely scattered and stunted conifer trees. The flora of intermittent wetlands is characteristically dominated by monocotyledons, with annual species contributing significantly to overall species diversity. For the majority of species, flowering and seed set occur in late summer and fall, when water levels are lowest. However, species with bog affinities found on bog mats within these wetlands tend to be spring-flowering.

Intermittent wetlands typically contain several vegetation zones, especially when they are adjacent to or encircle a lake or pond. The deepest portion of the depression is usually inundated and supports floating aquatic plants including water shield (*Brasenia schreberi*), yellow pond-lily (*Nuphar variegata*), sweet-scented water-lily (*Nymphaea odorata*), pondweeds (*Potamogeton* spp.), and bladderworts (*Utricularia* spp.). Occurring along the lower shores and pond margins is a seasonally flooded zone with sparse cover of low forbs and graminoids including pipewort (*Eriocaulon septangulare*), bright green spike-rush (*Eleocharis olivacea*), Robbin's spike-rush (*E. robbinsii*), autumn sedge (*Fimbristylis autumnalis*), brown-fruited rush (*Juncus pelocarpus*), beak-rushes (*Rhynchospora capitellata* and *R. fusca*), bulrush (*Schoenoplectus smithii*), and Torrey's bulrush (*Scirpus torreyi*, state special concern). In the saturated soil further from the shore, where the seasonal water levels typically reach their peak, is a dense graminoid-dominated zone. This is the most floristically diverse zone and typically includes species such as bluejoint grass (*Calamagrostis canadensis*), reedgrass (*C. stricta*), few-seed sedge (*Carex oligosperma*), wiregrass sedge (*C. lasiocarpa*), twig-rush (*Cladium mariscoides*), three-way sedge (*Dulichium arundinaceum*), grass-leaved goldenrod (*Euthamia graminifolia*), wild blue flag (*Iris versicolor*), swamp candles (*Lysimachia terrestris*), ticklegrass (*Agrostis hyemalis*), and panic grass (*Panicum lindheimeri*). Many intermittent wetlands contain a bog mat with vegetation typical of an ombrotrophic bog. These bog mats are characterized by sphagnum mosses, and low, ericaceous shrubs, with leatherleaf (*Chamaedaphne calyculata*) being the most prevalent. These bog mats are typically very low in herbaceous plant diversity. Trees within intermittent wetlands are typically absent or occur on the bog mat. Trees occurring on bog mats within the community are usually widely scattered and stunted conifers such as black spruce (*Picea mariana*) and tamarack (*Larix laricina*), and occasionally jack pine (*Pinus banksiana*) and white pine (*P. strobus*).

Noteworthy Animals

Beaver (*Castor canadensis*) and muskrat (*Ondatra zibethicus*) can profoundly influence the hydrology of intermittent wetlands. Muskrats create open water channels through peat, and beavers can cause substantial flooding through their dam-building activities.

Rare Plants

Bartonia paniculata (panicled screw-stem, state threatened)
Carex nigra (black sedge, state endangered)
Carex wiegandii (Wiegand's sedge, state special concern)
Eleocharis melanocarpa (black-fruited spike-rush, state special concern)
Gentiana linearis (narrow-leaved gentian, state threatened)
Gratiola virginiana (round-fruited hedge hyssop, state threatened)
Hemicarpha micrantha (dwarf bulrush, state special concern)
Huperzia selago (fir clubmoss, state special concern)
Juncus vaseyi (Vasey's rush, state threatened)
Juncus militaris (bayonet rush, state threatened)
Lycopodiella margueriteae (northern prostrate clubmoss, state special concern)
Lycopodiella subappressa (northern appressed clubmoss, state threatened)
Polygonum careyi (Carey's smartweed, state threatened)
Potamogeton bicupulatus (waterthread pondweed, state threatened)
Pycnanthemum verticillatum (whorled mountain mint, state special concern)
Ranunculus cymbalaria (seaside crowfoot, state threatened)
Sabatia angularis (rose pink, state threatened)
Scirpus clintonii (Clinton's bulrush, state special concern)
Scirpus torreyi (Torrey's bulrush, state special concern)

Rare Animals

Alces americanus (moose, state special concern)
Appalachia arcana (secretive locust, state special concern)
Ardea herodias (great blue heron, protected by the Migratory Bird Treaty Act of 1918)
Asio flammeus (short-eared owl, state endangered)
Boloria freija (Freija fritillary, state special concern)
Boloria frigga (Frigga fritillary, state special concern)
Botaurus lentiginosus (American bittern, state special concern)
Canis lupus (gray wolf, federal endangered and state threatened)
Circus cyaneus (northern harrier, state special concern)
Clemmys guttata (spotted turtle, state threatened)
Coturnicops noveboracensis (yellow rail, state threatened)
Emydoidea blandingii (Blanding's turtle, state special concern)
Erebia discoidalis (red-disked alpine, state special concern)
Falco columbarius (merlin, state threatened)
Gallinula chloropus (common moorhen, state threatened)
Gavia immer (common loon, state threatened)
Haliaeetus leucocephalus (bald eagle, state special concern)
Ixobrychus exilis (least bittern, state threatened)
Lynx canadensis (lynx, state endangered)
Merolonche dolli (Doll's merolonche, state special concern)
Pandion haliaetus (osprey, state special concern)
Phalaropus tricolor (Wilson's phalarope, state special concern)
Rallus elegans (king rail, state endangered)
Sistrurus c. catenatus (eastern massasauga, federal candidate species and state special concern)
Somatochlora incurvata (incurvate emerald, state special concern)
Terrapene c. carolina (eastern box turtle, state special concern)
Williamsonia fletcheri (ebony boghaunter, state special concern)

Biodiversity Management Considerations

Protection of the regional and local hydrologic regime is critical to the preservation of intermittent wetlands. Stabilization of water levels can allow for the establishment of perennials and woody species, which can displace less competitive annuals. Increased surface flow and alteration of groundwater recharge can be prevented by avoiding road construction and complete canopy removal in adjacent stands. A serious threat to intermittent wetland hydrology and species diversity is posed by off-road vehicle (ORV) traffic, which can significantly alter the hydrology through rutting and erosion. Soil erosion resulting from ORV use within the wetland or surrounding uplands may greatly disturb the seed bank, reducing plant density and diversity. Reduction of access to wetland systems will help decrease detrimental impacts from ORVs.⁷

Where shrub and tree encroachment threatens to convert open wetlands to shrub-dominated systems or forested swamps, prescribed fire can be employed to maintain open conditions. Prescribed fires are best employed in intermittent wetlands during droughts or in the late summer and fall when water levels are lowest. In addition to controlling woody invasion, fire promotes seed bank expression and rejuvenation and thus helps maintain species diversity. Intermittent wetlands are common natural features within a variety of droughty, fire-dependent, upland pine and oak matrix communities and would likely have experienced surface fires along with the surrounding uplands when conditions were favorable. When feasible, prescribed fires conducted in the adjacent uplands should be allowed to carry into intermittent wetlands.

Monitoring and control efforts to detect and remove invasive species are critical to the long-term viability of intermittent wetland. Invasive species that threaten the diversity and community structure of intermittent wetlands include reed (*Phragmites australis*), reed canary grass (*Phalaris arundinacea*), narrow-leaved cat-tail (*Typha angustifolia*), hybrid cat-tail (*Typha xglauca*), purple loosestrife (*Lythrum salicaria*), glossy buckthorn (*Rhamnus frangula*), and multiflora rose (*Rosa multiflora*).

Variation

Species composition of intermittent wetlands varies depending on fluctuating water levels and fire disturbance.

Similar Natural Communities

Bog, coastal plain marsh, emergent marsh, northern fen, northern wet meadow, poor fen, and submergent marsh.

Relevant Literature

- Boelter, D.H., and E.S. Verry. 1977. Peatland and water in the northern Lake States. North Central Forest Experiment Station. USDA, Forest Service General Technical Report NC-31. 26 pp.
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- Zoltai, S.C., and D.H. Vitt. 1995. Canadian wetlands: Environmental gradients and classification. *Vegetatio* 118: 131-137.

For a full list of references used to create this description, please refer to the natural community abstract for intermittent wetland.

Coastal Plain Marsh

Global/State Rank: G2/S2

Overview

Coastal plain marsh is a grass-, spike-rush-, and rush-dominated wetland community that contains numerous plant disjuncts from the Atlantic and Gulf coastal plains. The community occurs in depressions on sand deposits associated with postglacial lakes and outwash channels in western Lower Michigan, northern Indiana, northern and central Wisconsin, and the southeastern Georgian Bay region of Ontario.

Landscape Context

Coastal plain marshes occur in depressions in sandy, acidic, pitted outwash plains and lakeplains. They are often found along the shores of softwater seepage lakes, ponds, and depressions, where water levels fluctuate both seasonally and yearly. Coastal plain marsh may be bordered by other wetland communities such as a floating bog, lakeplain prairie, wet-mesic sand prairie, shrub-carr, or southern hardwood swamp. Today, most coastal plain marshes are bordered by closed-canopy dry southern forest, dry-mesic southern forest, and dry-mesic northern forest. However, in the 1800s, prior to fire suppression, the uplands bordering coastal plain marshes supported a variety of open-canopy, fire-dependent communities including oak openings, lakeplain oak openings, bur oak plains, oak barrens, oak-pine barrens, dry sand prairie, mesic sand prairie, and dry-mesic prairie.

Soils

The sandy soils underlying coastal plain marshes are strongly to very strongly acidic and nutrient-poor. Organic deposits of peat or sandy peat may overlay the sandy substrate, and in some basins a clay layer may occur several meters below the surface.

Natural Processes

The dominant natural processes in coastal plain marshes are seasonal and yearly water level fluctuations. Seasonally, water levels tend to be highest during the winter and spring and lowest in late summer and early autumn. Yearly water level fluctuations are less predictable. Fluctuating water levels facilitate seed germination by drawing down water levels and thus allowing direct sunlight to penetrate the exposed pond shore and trigger seed germination. Fluctuating water levels also limit competition from woody plants and are an important mechanism for seed and nutrient dispersal to the outer margins of the wetland basin.

Historically, during low-water years, fire likely carried from adjacent uplands into coastal plain marshes. Because fire has been shown to increase seed germination, enhance seedling establishment, and bolster flowering, it likely acted as an important mechanism for maintaining plant species diversity and replenishing seed banks.

Long distance seed dispersal among Midwest coastal plain marshes and between the Midwest and Atlantic and Gulf coastal plains is thought to be facilitated by migratory waterfowl. Waterfowl moving among nearby wetlands may also restore species that have been depleted from a site's seed bank.

Vegetation

Coastal plain marshes typically contain four distinct vegetation zones, often occurring as concentric bands around the open water portions of depressions, lakes, and ponds. The deepest portion of the depression is usually inundated and supports floating aquatic plants such as water shield (*Brasenia schreberi*), sweet-scented water-lily (*Nymphaea odorata*), pondweeds (*Potamogeton* spp.), and bladderworts (*Utricularia* spp.). Along the shoreline is a seasonally flooded zone that supports a sparse graminoid cover of species such as tall beak-rush (*Rhynchospora macrostachya*, state special concern) and autumn sedge (*Fimbristylis autumnalis*). In the saturated soils further from shore is a dense graminoid-dominated zone of bluejoint grass (*Calamagrostis canadensis*), twig-rush (*Cladium mariscoides*), coastal flat-topped goldenrod (*Euthamia remota*), beak-rush (*Rhynchospora capitellata*), and others. Lastly, many coastal plain marshes contain a temporarily flooded shrub and tree zone with black chokeberry (*Aronia prunifolia*), buttonbush (*Cephalanthus occidentalis*), dogwoods (*Cornus* spp.), and steplebush (*Spiraea tomentosa*). In addition to the above, the following species are characteristic of coastal plain marsh: three-awned grass (*Aristida necopina*), bushy aster (*Aster dumosus*), sedge (*Bulbostylis capillaris*), umbrella sedge (*Cyperus rivularis*), Robin's spike-rush (*Eleocharis robbinsii*), pipewort (*Eriocaulon septangulare*), dwarf bulrush (*Hemicarpha micrantha*, state special concern), Canadian St. John's-wort (*Hypericum canadense*), two-flowered rush (*Juncus biflorus*, state threatened), brown-fruited rush (*Juncus pelocarpus*), round-headed rush (*Juncus scirpoides*), bog clubmoss (*Lycopodiella inundata*), panic grass (*Panicum spretum*), beak-rush (*Rhynchospora capitellata*), tooth-cup (*Rotala ramosior*), tall nut-rush (*Scleria triglomerata*), bulrush (*Schoenoplectus smithii*), little ladies'-tresses (*Spiranthes tuberosa*), Virginia marsh St. John's-wort (*Triadenum virginicum*), lance-leaved violet (*Viola lanceolata*), and yellow-eyed-grass (*Xyris torta*).

Noteworthy Animals

Seasonally inundated coastal plain marshes provide breeding habitat for amphibians and are important feeding areas for shorebirds and waterfowl.

Rare Plants

Bartonia paniculata (panicled screw-stem, state threatened)
Carex albolutescens (greenish-white sedge, state threatened)
Carex festucacea (fescue sedge, state special concern)
Echinodorus tenellus (dwarf burhead, state endangered)
Eleocharis atropurpurea (purple spike-rush, state special concern)
Eleocharis engelmannii (Engelmann's spike-rush, state special concern)
Eleocharis melanocarpa (black-fruited spike-rush, state special concern)
Eleocharis microcarpa (small-fruited spike-rush, state endangered)
Eleocharis tricostata (three-ribbed spike-rush, state threatened)
Fuirena squarrosa (umbrella grass, state threatened)
Gratiola virginiana (round-fruited hedge hyssop, state threatened)
Hemicarpha micrantha (dwarf bulrush, state special concern)
Hypericum adpressum (Creeping St. John's-wort, state threatened)
Isoetes engelmannii (Engelmann's quillwort, state endangered)
Juncus brachycarpus (short-fruited rush, state threatened)
Juncus scirpoides (round-headed rush, state threatened)
Lechea minor (least pinweed, presumed extirpated from Michigan)
Lechea pulchella (Leggett's pinweed, state threatened)
Ludwigia sphaerocarpa (globe-fruited seedbox, state threatened)
Lycopodiella margueriteae (northern prostrate clubmoss, state threatened)
Lycopodiella subappressa (appressed bog clubmoss, state special concern)

Panicum longifolium (long-leaved panic grass, state threatened)
Panicum verrucosum (warted panic grass, state threatened)
Polygala cruciata (cross-leaved milkwort, state special concern)
Polygonum careyi (Carey's smartweed, state threatened)
Potamogeton bicupulatus (waterthread pondweed, state threatened)
Proserpinaca pectinata (mermaid-weed, state endangered)
Psilocarya scirpoides (bald-rush, state threatened)
Pycnanthemum verticillatum (whorled mountain mint, state special concern)
Rhexia mariana var. *mariana* (Maryland meadow beauty, state threatened)
Rhexia virginica (meadow beauty, state special concern)
Rhynchospora macrostachya (tall beak-rush, state special concern)
Rhynchospora nitens (short-beak beak-rush, state endangered)
Rhynchospora recognita (globe beak-rush, state endangered)
Sabatia angularis (rose pink, state threatened)
Scirpus hallii (Hall's bulrush, state threatened)
Scirpus torreyi (Torrey's bulrush, state special concern)
Scleria pauciflora (few-flowered nut-rush, state endangered)
Scleria reticularis (netted nut-rush, state threatened)
Scleria triglomerata (tall nut-rush, state special concern)
Sisyrinchium atlanticum (Atlantic blue-eyed-grass, state threatened)
Sisyrinchium strictum (blue-eyed-grass, state special concern)
Utricularia inflata (floating bladderwort, state endangered)

Rare Animals

Acris blanchardi (Blanchard's cricket frog, state threatened)
Botaurus lentiginosus (American bittern, state special concern)
Chlidonias niger (black tern, state special concern)
Circus cyaneus (northern harrier, state special concern)
Cistothorus palustris (marsh wren, state special concern)
Clemmys guttata (spotted turtle, state threatened)
Cordulegaster erronea (tiger spiketail, state special concern)
Cygnus buccinator (trumpeter swan, state threatened)
Dorydiella kansana (leafhopper, state special concern)
Emydoidea blandingii (Blanding's turtle, state special concern)
Gallinula chloropus (common moorhen, state threatened)
Ixobrychus exilis (least bittern, state threatened)
Meropleon ambifusca (Newman's brocade, state special concern)
Nycticorax nycticorax (black-crowned night-heron, state special concern)
Orphulella p. pelidna (green desert grasshopper, state special concern)
Paroxya hoosieri (Hoosier locust, state special concern)
Phalaropus tricolor (Wilson's phalarope, state special concern)
Rallus elegans (king rail, state endangered)
Sistrurus c. catenatus (eastern massasauga, federal candidate species and state special concern)
Tyto alba (barn owl, state endangered)

Biodiversity Management Considerations

Given that even small changes in hydroperiod can cause significant shifts in wetland community composition and structure, protection of the regional and local hydrologic regime is critical to the long-term preservation of coastal plain marshes. If water levels are stabilized, perennials and woody species may become established, displacing less competitive annuals and coastal plain specialists.

Coastal plain marshes occur as shallow depressions within a fire-dependent matrix of upland forest and barrens. Prescribed fire management of coastal plain marsh, which should include burning adjacent wetland and upland communities, can be used to stimulate seed germination and flowering, reduce encroachment of woody plants, and maintain a diverse seed bank.

Coastal plain marshes are threatened by off-road vehicles and fire suppression. Off-road vehicles can greatly disturb the seed bank, alter surface hydrology, and create open microsites that are easily colonized by non-native plants. Fire suppression facilitates shrub and tree establishment during low water years and allows for the build up of a thick layer of litter, which stifles seed germination and seedling establishment. As coastal plain marshes contain a unique suite of coastal plain disjuncts, the loss of any single marsh may negatively impact population dynamics at other sites by eliminating opportunities for genetic exchange and recolonization.

Monitoring and control efforts to detect and remove invasive species are critical to the long-term viability of coastal plain marsh. Particularly aggressive invasive species that may colonize the edges or interior of coastal plain margins and thereby threaten diversity and community structure include garlic mustard (*Alliaria petiolata*), reed (*Phragmites australis*), reed canary grass (*Phalaris arundinacea*), narrow-leaved cat-tail (*Typha angustifolia*), hybrid cat-tail (*Typha xglauca*), purple loosestrife (*Lythrum salicaria*), glossy buckthorn (*Rhamnus frangula*), and multiflora rose (*Rosa multiflora*).

Variation

Community size, basin morphology, presence and depth of water, and plant species composition can all vary significantly among coastal plain marshes, even where they occur in proximity to one another.

Similar Natural Communities

Intermittent wetland, wet-mesic sand prairie, and wet-mesic prairie.

Relevant Literature

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For a full list of references used to create this description, please refer to the natural community abstract for coastal plain marsh.

Interdunal Wetland

Global/State Rank: G2/S2

Overview

Interdunal wetland is a rush-, sedge-, and shrub-dominated wetland situated in depressions within open dunes or between beach ridges along the Great Lakes, experiencing a fluctuating water table seasonally and yearly in synchrony with lake level changes.

Landscape Context

This natural community is typically found in long troughs or swales between dune ridges, in wind-formed depressions at the base of blowouts, in hollows of dune fields, and in abandoned river channels that once flowed parallel to the lakeshore behind a foredune. Interdunal wetlands occur on all of the Laurentian Great Lakes.

Soils

The saturated sand and pond water of interdunal wetlands along the lower Great Lakes is neutral to moderately alkaline because of traces of calcareous minerals in the lake-edge sands. The sand, which is sometimes covered by a thin layer of muck, is similar in composition to that of the surrounding beach ridges or dunes, consisting largely of quartz with lesser amounts of feldspar, magnetite, and traces of other minerals, such as calcite, garnet, and hornblende. On Lake Superior, there is little or no calcite, and alkalinity is typically lower than in the other Great Lakes. In the Straits of Mackinac region, the underlying soil in interdunal wetlands is sometimes fine-textured loams or clays rich in calcium carbonate. Carbonate-rich groundwater flows from adjacent sand dunes or nearby limestone or dolomite uplands, providing nutrients for rapid growth of stonewort (*Chara* spp.) and other algae. The metabolism of these algae produces calcium carbonate, which precipitates as a fine, white mud-like substance called marl. As marl deposits accumulate, sometimes reaching more than a meter in depth, they facilitate the formation of northern fen.

Natural Processes

The water-level fluctuations of the adjacent Great Lakes are important for the dynamics of the interdunal wetlands. Interdunal wetlands are formed when water levels of the Great Lakes drop, creating a swale or linear depression between the inland foredune and the newly formed foredune along the water's edge. When Great Lakes water levels rise or during storm events, the interdunal wetland closest to the shoreline can be partially or completely buried by sand. Summer heating and evaporation can result in warm, shallow water or even complete drying within the swale. Where shallow standing water overlays fine-textured substrates within the swales, precipitation of calcium carbonate in the form of marl is common.

Vegetation

The data used for this description are almost exclusively from narrow interdunal wetlands along the Great Lakes shoreline, with little data from hollows or depressions in dune fields and no data from large inland lakes. Dominant plants include Baltic rush (*Juncus balticus*) and twig-rush (*Cladium mariscoides*), both species able to survive sand burial and water level fluctuations. Some other common plants are Kalm's lobelia (*Lobelia kalmii*), horned bladderwort (*Utricularia cornuta*), common bog arrow-grass (*Triglochin maritimum*), Kalm's St. John's-wort (*Hypericum kalmianum*), false asphodel (*Tofieldia glutinosa*), golden-seeded spike-rush (*Eleocharis elliptica*), grass-leaved goldenrod (*Euthamia graminifolia*), shrubby cinquefoil (*Potentilla fruticosa*), three-

square (*Schoenoplectus pungens*), bluejoint grass (*Calamagrostis canadensis*), beak-rush (*Rhynchospora capillacea*), and seedling or shrub-size northern white-cedar (*Thuja occidentalis*). Other typical species include several sedges (*Carex aquatilis*, *C. garberi*, *C. viridula*, *C. lasiocarpa*, and *C. stricta*), small fringed gentian (*Gentianopsis procera*), blue-leaf willow (*Salix myricoides*), geocaulon (*Geocaulon lividum*), purple gerardia (*Agalinis purpurea*), balsam ragwort (*Senecio pauperculus*), Houghton's goldenrod (*Solidago houghtonii*, state threatened), Ohio goldenrod (*S. ohioensis*), silverweed (*Potentilla anserina*), grass-of-Parnassus (*Parnassia glauca*), variegated scouring rush (*Equisetum variegatum*), sweet gale (*Myrica gale*), tamarack (*Larix laricina*), spike-rush (*Eleocharis quinqueflora*), hardstem bulrush (*Schoenoplectus acutus*), pitcher-plant (*Sarracenia purpurea*), sand dune willow (*Salix cordata*), Indian paintbrush (*Castilleja coccinea*), swamp candles (*Lysimachia terrestris*), dwarf Canadian primrose (*Primula mistassinica*), smooth scouring rush (*Equisetum laevigatum*), red-osier dogwood (*Cornus stolonifera*), low calamint (*Calamintha arkansana*), tag alder (*Alnus rugosa*), ticklegrass (*Agrostis hyemalis*), marsh cinquefoil (*Potentilla palustris*), rose pogonia (*Pogonia ophioglossoides*), jack pine (*Pinus banksiana*), marsh pea (*Lathyrus palustris*), hair grass (*Deschampsia cespitosa*), slender bog arrow-grass (*Triglochin palustris*), panic grass (*Panicum lindheimeri*), and marsh bellflower (*Campanula aparinoides*).

The coastal swales often show little zonation, although the larger, deeper swales can have shrubs and herbs along their edges, with emergent bulrushes, spike-rushes, and cat-tails in the shallow water, and submergent and floating plants in the deepest water at the center of the swale. In dry years, the entire wetland may be only moist or dry, in which case many plants from the adjacent beach ridges can establish. Wetlands among parabolic dunes are often drier, supporting a greater percentage of shrubs and sometimes trees. When trees become dominant, the plant community may be classified as Great Lakes barrens, where the swales are located in parabolic dune fields, or as wooded dune and swale complex, where it occurs as a series of parallel swales and low beach ridges.

Noteworthy Animals

These quickly warming wetlands provide important feeding areas for migrating shorebirds, waterfowl, and songbirds in the spring. They are also important foraging areas for waterfowl in the fall. Spotted sandpipers (*Actitis macularia*) breed along the margins of interdunal wetlands, and piping plovers (*Charadrius melodus*) forage at the edges of these wetlands. Great blue herons (*Ardea herodias*) regularly feed on invertebrates in the swales. Among the invertebrates occupying interdunal wetlands are dragonflies (Suborder *Anisoptera*), damselflies (Suborder *Zygoptera*), midges (Family *Chironomidae*), and probably many others. Leeches (Family *Hirundinae*) are commonly observed invertebrates in the warm, shallow waters of interdunal swales along Lakes Michigan and Huron.

Rare Plants

Lycopodiella subappressa (northern appressed clubmoss, state special concern)

Pinguicula vulgaris (butterwort, state special concern)

Potamogeton bicipulatus (waterthread pondweed, state threatened)

Sarracenia purpurea ssp. *heterophylla* (yellow pitcher-plant, state threatened)

Solidago houghtonii (Houghton's goldenrod, federal threatened)

Tanacetum huronense (Lake Huron tansy, state threatened)

Utricularia inflata (floating bladderwort, state endangered)

Utricularia subulata (zigzag bladderwort, state threatened)

Rare Animals

Acris blanchardi (Blanchard's cricket frog, state threatened)
Ardea herodias (great blue heron, protected by the Migratory Bird Treaty Act of 1918)
Catinella exile (Pleistocene catinella, state threatened)
Clemmys guttata (spotted turtle, state threatened)
Emydoidea blandingii (Blanding's turtle, state special concern)
Oncocnemis piffardi (three-striped onconemi, state special concern)
Orchelimum delicatum (delicate meadow katydid, state special concern)
Papaipema aweme (aweme borer, state special concern)
Somatochlora hineana (Hine's emerald, federal/state endangered)

Biodiversity Management Considerations

Off-road vehicles can damage or destroy the vegetation and habitat of interdunal wetlands, as documented at several sites along the northern Lake Michigan and Lake Huron shorelines. Heavy human usage of the adjacent beach can also threaten associated fauna, such as piping plover and other shorebirds.

Monitoring and control efforts to detect and remove invasive species are critical to the long-term viability of interdunal wetland. Invasive species that may threaten diversity and community structure include reed (*Phragmites australis*), reed canary grass (*Phalaris arundinacea*), narrow-leaved cat-tail (*Typha angustifolia*), hybrid cat-tail (*Typha xglauca*), purple loosestrife (*Lythrum salicaria*), spotted knapweed (*Centaurea maculosa*), baby's breath (*Gypsophila paniculata*), common St. John's-wort (*Hypericum perforatum*), ox-eye daisy (*Chrysanthemum leucanthemum*), bull thistle (*Cirsium vulgare*), white sweet-clover (*Melilotus alba*), Japanese knotweed (*Polygonum cuspidatum*), hoary alyssum (*Berteroa incana*), Kentucky bluegrass (*Poa pratensis*), Canada bluegrass (*P. compressa*), quack grass (*Agropyron repens*), hawkweeds (*Hieracium* spp.), sheep sorrel (*Rumex acetosella*), black locust (*Robinia pseudoacacia*), white poplar (*Populus alba*), Lombardy poplar (*P. nigra* var. *italica*), common buckthorn (*Rhamnus cathartica*), glossy buckthorn (*Rhamnus frangula*), autumn olive (*Elaeagnus umbellata*), Eurasian honeysuckles (*Lonicera morrowii*, *L. japonica*, *L. maackii*, *L. sempervirens*, *L. tatarica*, *L. xbella*, and *L. xylosteum*), and multiflora rose (*Rosa multiflora*).

Variation

Interdunal wetlands located further inland in dune fields are less subject to water-level fluctuations linked to the Great Lakes, and also much less subject to being filled by moving sand during storms. As a result they often have deeper organic soils, as well as greater dominance by shrubs and occasionally small trees. Unlike the interdunal wetlands of the lower Great Lakes, those along the shores of Lake Superior are not buffered by calcium carbonate; as a result, Lake Superior interdunal wetlands often become acidic and support a flora with more acid-tolerant shrubs and small trees, including leatherleaf (*Chamaedaphne calyculata*), black chokeberry (*Aronia prunifolia*), bog rosemary (*Andromeda glaucophylla*), Labrador tea (*Ledum groenlandicum*), and black spruce (*Picea mariana*), along with more acid-tolerant sedges, such as boreal bog sedge (*Carex paupercula*). Sphagnum mosses are a major component in some Lake Superior interdunal wetlands. Interdunal wetlands also form between irregularly formed sand spits, as at Whitefish Point on Lake Superior, where hundreds of small wetlands have formed. The flora of these wetlands share many of the more acid-tolerant shrubs already described for Lake Superior, but no data have been collected on this large wetland complex.

Similar Natural Communities

Coastal fen, limestone cobble shore, northern fen, prairie fen, wooded dune and swale complex, and Great Lakes barrens.

Relevant Literature

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- Albert, D.A. 2007. Natural community abstract for interdunal wetland. Michigan Natural Features Inventory, Lansing, MI. 6 pp.
- Comer, P.J., and D.A. Albert. 1993. A survey of wooded dune and swale complexes in Michigan. Michigan Natural Features Inventory report to Michigan Department of Natural Resources, Land and Water Management Division, Coastal Zone Management Program. 159 pp.
- Faber-Langendoen, D., ed. 2001. Plant communities of the Midwest: Classification in an ecological context. Association for Biodiversity Information, Arlington, VA. 61 pp. + appendix (705 pp.).
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- Lichter, J. 1998. Primary succession and forest development on coastal Lake Michigan sand dunes. Ecological Monographs 68: 487-510.
- Soluk, D.A., B.J. Swisher, D.S. Zercher, J.D. Miller, and A.B. Hults. 1998. The ecology of Hine's emerald dragonfly (*Somatochlora hineana*): Monitoring populations and determining patterns of habitat use. Activity summary and report of findings (September 1996–August 1997). Illinois Natural History Survey, Champaign, IL. 111 pp.
- Zercher, D. 1999. Hine's emerald dragonfly (*Somatochlora hineana*) draft recovery plan. Report to USFWS, Fort Snelling, MN. 110 pp.

For a full list of references used to create this description, please refer to the natural community abstract for interdunal wetland.

WET PRAIRIE COMMUNITIES

Wet Prairie

Global/State Rank: G3/S2

Overview

Wet prairie is a native lowland grassland occurring on level, saturated and/or seasonally inundated stream and river floodplains, lake margins, and isolated depressions in southern Lower Michigan. It is typically found on outwash plains and channels near moraines. Soils are primarily loam or silt loam of neutral pH and have high organic content. Dominant species include bluejoint grass (*Calamagrostis canadensis*) and cordgrass (*Spartina pectinata*), with sedges (*Carex* spp.) often important subdominants.

Landscape Context

Wet prairie occurs on outwash plains and channels, typically near coarse-textured moraines, within stream or river floodplains, lake margins, and isolated depressions. It is associated with uplands characterized by dry and dry-mesic southern forests, and prior to European settlement, with savanna and prairie communities such as oak openings, oak barrens, mesic prairie, and dry-mesic prairie.

Soils

Soils are typically sandy loam or silt loam but can also be silty clay or clay. Soils are characterized by neutral pH, high organic content, and good water-retaining capacity. Organic deposits (muck) are absent or form only a thin layer over mineral soil.

Natural Processes

Water level fluctuations and fire help maintain diversity and open conditions. Seasonal saturation or inundation through flooding, ponding, or high water tables restricts shrub and tree establishment. Beaver can reduce shrub and tree cover by causing flooding, raising local water tables, and through herbivory. Prior to European settlement in the early 1800s, fires of natural and anthropogenic origin limited encroachment by shrubs and trees that established despite the unfavorable hydrologic conditions. Fire helps maintain species diversity by facilitating seed germination, opening microsites for seedling establishment and growth of small species, and releasing important plant nutrients that bolster plant growth, flowering, and seed set.

Vegetation

Dominant grasses are bluejoint grass and cordgrass, with sedges (*Carex stricta* and *C. bebbii*) often important subdominants. Big bluestem (*Andropogon gerardii*) and Indian grass (*Sorghastrum nutans*) may appear in areas transitional to wet-mesic prairie. Other characteristic species include hog-peanut (*Amphicarpaea bracteata*), angelica (*Angelica atropurpurea*), groundnut (*Apios americana*), New England aster (*Aster novae-angliae*), fringed brome (*Bromus ciliatus*), marsh marigold (*Caltha palustris*), joe-pye-weed (*Eupatorium maculatum*), common boneset (*E. perfoliatum*), fowl manna grass (*Glyceria striata*), tall sunflower (*Helianthus giganteus*), star-grass (*Hypoxis hirsute*), marsh pea (*Lathyrus palustris*), Michigan lily (*Lilium michiganense*), fringed loosestrife (*Lysimachia ciliata*), leafy satin grass (*Muhlenbergia mexicana*), cowbane (*Oxypolis rigidior*), Virginia mountain mint (*Pycnanthemum virginianum*), black-eyed Susan (*Rudbeckia hirta*), swamp saxifrage (*Saxifraga pennsylvanica*), starry false Solomon's seal (*Smilacina stellata*), tall goldenrod (*Solidago altissima*), Canada goldenrod (*S.*

canadensis), late goldenrod (*S. gigantea*), Riddell's goldenrod (*S. riddellii*), purple meadow rue (*Thalictrum dasycarpum*), marsh fern (*Thelypteris palustris*), and broad-leaved cat-tail (*Typha latifolia*). Common shrubs include dogwoods (*Cornus* spp.), ninebark (*Physocarpus opulifolius*), and willows (*Salix* spp.); these may be dense due to fire suppression and/or hydrologic alteration. The invasive species, reed canary grass (*Phalaris arundinacea*), is common in some sites. Diversity varies, in part depending on duration of seasonal inundation, time since last fire, and abundance of invasive species.

Noteworthy Animals

Beaver (*Castor canadensis*) can cause flooding that substantially alters wetlands and results in conversion of southern shrub-carr and lowland forest systems to ponds, emergent marsh, southern wet meadow, wet prairie, or wet-mesic prairie, depending on landscape position, soils, and depth and duration of flooding.

Rare Plants

Dodecatheon meadia (shooting star, state endangered)
Eryngium yuccifolium (rattlesnake-master, state threatened)
Mimulus alatus (wing-stemmed monkey-flower, presumed extirpated from Michigan)
Polemonium reptans (Jacob's ladder, state threatened)
Pycnanthemum muticum (broad-leaved mountain mint, state threatened)
Sanguisorba canadensis (Canadian burnet, state endangered)
Silphium integrifolium (rosinweed, state threatened)
Sisyrinchium farwellii (Farwell's blue-eyed-grass, presumed extirpated from Michigan)

Rare Animals

Acris blanchardi (Blanchard's cricket frog, state threatened)
Ambystoma texanum (smallmouth salamander, state endangered)
Ammodramus savannarum (grasshopper sparrow, state special concern)
Asio flammeus (short-eared owl, state endangered)
Botaurus lentiginosus (American bittern, state special concern)
Circus cyaneus (northern harrier, state special concern)
Clemmys guttata (spotted turtle, state threatened)
Clonophis kirtlandii (Kirtland's snake, state endangered)
Dorydiella kansana (leafhopper, state special concern)
Emydoidea blandingii (Blanding's turtle, state special concern)
Flexamia reflexus (leafhopper, state special concern)
Meropleon ambifusca (Newman's brocade, state special concern)
Neoconocephalus lyristes (bog conehead, state special concern)
Neoconocephalus retusus (conehead grasshopper, state special concern)
Neonympha m. mitchellii (Mitchell's satyr, federal/state endangered)
Orchelimum concinnum (red-faced meadow katydid, state special concern)
Orphulella pelidna (green desert grasshopper, state special concern)
Papaipema cerina (golden borer, state special concern)
Papaipema maritima (maritime sunflower borer, state special concern)
Papaipema speciosissima (regal fern borer, state special concern)
Paroxya hoosieri (Hoosier locust, state special concern)
Phalaropus tricolor (Wilson's phalarope, state special concern)
Sistrurus c. catenatus (eastern massasauga, federal candidate species and state special concern)
Spartiniphaga inops (spartina moth, state special concern)
Spiza americana (dickcissel, state special concern)
Tyto alba (barn owl, state endangered)

Biodiversity Management Considerations

The majority of wet prairie acreage was converted to agriculture following European settlement. Threats to remaining sites include hydrologic alteration, nutrient enrichment, siltation, fire suppression, shrub and tree encroachment, and destruction of upland buffers. Fire suppression and hydrologic alterations such as ditching and tiling promote shrub and tree invasion, which results in reduced cover of graminoids and the fine-fuels needed to carry a fire. Invasive plants are favored by nutrient enrichment, fire suppression, and hydrologic alteration. Invasive species that threaten the diversity and community structure of wet prairie include glossy buckthorn (*Rhamnus frangula*), multiflora rose (*Rosa multiflora*), autumn olive (*Elaeagnus umbellata*), reed (*Phragmites australis*), reed canary grass (*Phalaris arundinacea*), narrow-leaved cat-tail (*Typha angustifolia*), hybrid cat-tail (*Typha xglauca*), and purple loosestrife (*Lythrum salicaria*). Prescribed fire, in conjunction with cutting and/or herbiciding of invasive species, can be used to maintain biodiversity of lowland grasslands. Some sites may require hydrologic restoration and efforts to restrict nutrient and sediment inputs. In addition, restoration of upland natural communities bordering wet prairie occurrences should be conducted to improve hydrology and provide refugia for flood-intolerant species during periods of high water.

Variation

Species dominance varies among bluejoint, cordgrass, sedges, and native forbs. Some occurrences are associated with seasonal flooding, others apparently flood only rarely or not at all. Sites with big bluestem and/or Indian grass as dominants or subdominants may represent wet-mesic prairie.

Similar Natural Communities

Wet-mesic prairie, lakeplain wet prairie, lakeplain wet-mesic prairie, wet-mesic sand prairie, and southern wet meadow.

Relevant Literature

- Chapman, K.A. 1984. An ecological investigation of native grassland in southern Lower Michigan. M.A. thesis, Western Michigan University, Kalamazoo, MI.
- Fraser, A., and K. Kindscher. 2005. Spatial distribution of *Spartina pectinata* transplants to restore wet prairie. *Restoration Ecology* 13: 144-151.
- Galatowitsch, S.M., D.C. Whited, R. Lehtinen, J. Husveth, and K. Schik. 2000. The vegetation of wet meadows in relation to their land-use. *Environmental Monitoring and Assessment* 60: 121-144.
- Kercher, S.M., and J.B. Zedler. 2004. Flood tolerance in wetland angiosperms: A comparison of invasive and noninvasive species. *Aquatic Botany* 80: 89-102.
- Kercher, S.M., and J.B. Zedler. 2004. Multiple disturbances accelerate invasion of reed canary grass (*Phalaris arundinacea* L.) in a mesocosm study. *Oecologia* 138: 455-464.
- NatureServe. 2006. NatureServe Explorer: An online encyclopedia of life [Web application]. Version 6.1. NatureServe, Arlington, VA. Available <http://www.natureserve.org/explorer>. (Accessed: January 3, 2007.)
- Thompson, P.W. 1968. A wet prairie community in Ann Arbor, Michigan. *Michigan Academician* 2: 87-94.

For a full list of references used to create this description, please refer to the natural community abstract for wet prairie.

Wet-mesic Prairie

Global/State Rank: G2/S2

Overview

Wet-mesic prairie is a native lowland grassland occurring on moist, occasionally inundated stream and river floodplains, lake margins, and isolated depressions in southern Lower Michigan. It is typically found on outwash plains and channels near moraines. Soils are primarily loam or silt loam with neutral pH and high organic content. Dominants or subdominants include big bluestem (*Andropogon gerardii*), Indian grass (*Sorghastrum nutans*), bluejoint grass (*Calamagrostis canadensis*), cordgrass (*Spartina pectinata*), and sedges (*Carex* spp.).

Landscape Context

Wet-mesic prairie occurs on outwash plains and channels, typically near coarse-textured moraines, within stream or river floodplains, isolated depressions, and along lake margins. It is associated with uplands characterized by dry and dry-mesic southern forest, and prior to European settlement, oak savannas and prairie.

Soils

Soils are typically loam or silt loam and less frequently sandy loam, silty clay, or clay. Soils are characterized by neutral pH, with high organic content, and good water-retaining capacity. Organic deposits (muck) are absent or form only a thin layer over mineral soil.

Natural Processes

Water level fluctuations and fire help maintain diversity and open conditions. Seasonal saturation or inundation through flooding, ponding, or high water tables restricts shrub and tree establishment. Beaver can reduce shrub and tree cover by causing flooding, raising local water tables, and through herbivory. Prior to European settlement in the early 1800s, fires of natural and anthropogenic origin limited encroachment by shrubs and trees that established despite the unfavorable hydrologic conditions. Fire helps maintain species diversity by facilitating seed germination, opening microsites for seedling establishment and growth of small species, and releasing important plant nutrients that bolster plant growth, flowering, and seed set.

Vegetation

Dominant grasses are typically big bluestem and Indian grass, with bluejoint, cordgrass, and sedges (*C. bebbii*, *C. stricta*, etc.) often subdominant or common, especially in areas transitional to wet prairie. Other characteristic species include thimbleweed (*Anemone virginiana*), New England aster (*Aster novae-angliae*), common horsetail (*Equisetum arvense*), rattlesnake-master (*Eryngium yuccifolium*), grass-leaved goldenrod (*Euthamia graminifolia*), wild strawberry (*Fragaria virginiana*), northern bedstraw (*Galium boreale*), bottle gentian (*Gentiana andrewsii*), Virginia mountain mint (*Pycnanthemum virginianum*), yellow coneflower (*Ratibida pinnata*), black-eyed Susan (*Rudbeckia hirta*), prairie dock (*Silphium terebinthinaceum*), purple meadow rue (*Thalictrum dasycarpum*), and Culver's root (*Veronicastrum virginicum*). Sites associated with prairie fen harbor calciphiles such as purple gerardia (*Agalinis purpurea*), small fringed gentian (*Gentianopsis crinita*), Kalm's lobelia (*Lobelia kalmii*), grass-of-Parnassus (*Parnassia glauca*), and shrubby cinquefoil (*Potentilla fruticosa*). Common shrubs include silky dogwood (*Cornus amomum*), gray dogwood (*C. foemina*), red-osier dogwood (*C. stolonifera*), ninebark (*Physocarpus opulifolius*), and willows (*Salix* spp.); these may be dense due to fire suppression

and/or hydrologic alteration. Diversity varies, in part depending on duration of seasonal inundation and time since last fire.

Noteworthy Animals

Beaver (*Castor canadensis*) can cause flooding that substantially alters wetland community structure, converting lowland shrub and forest systems to pond, emergent marsh, wet meadow, wet prairie, wet-mesic prairie, and wet-mesic sand prairie, depending on landscape position, soils, and depth and duration of flooding.

Rare Plants

Dodecatheon meadia (shooting star, state endangered)
Eryngium yuccifolium (rattlesnake-master, state threatened)
Mimulus alatus (wing-stemmed monkey-flower, presumed extirpated from Michigan)
Polemonium reptans (Jacob's ladder, state threatened)
Polygala incarnata (pink milkwort, presumed extirpated from Michigan)
Pycnanthemum muticum (broad-leaved mountain mint, state threatened)
Rudbeckia subtomentosa (sweet coneflower, presumed extirpated from Michigan)
Scleria triglomerata (tall nut-rush, state special concern)
Silphium integrifolium (rosinweed, state threatened)
Sisyrinchium farwellii (Farwell's blue-eyed-grass, presumed extirpated from Michigan)

Rare Animals

Ammodramus savannarum (grasshopper sparrow, state special concern)
Asio flammeus (short-eared owl, state endangered)
Botaurus lentiginosus (American bittern, state special concern)
Circus cyaneus (northern harrier, state special concern)
Clemmys guttata (spotted turtle, state threatened)
Clonophis kirtlandii (Kirtland's snake, state endangered)
Dorydiella kansana (leafhopper, state special concern)
Emydoidea blandingii (Blanding's turtle, state special concern)
Meropleon ambifusca (Newman's brocade, state special concern)
Neoconocephalus lyristes (bog conehead, state special concern)
Neoconocephalus retusus (conehead grasshopper, state special concern)
Neonympha m. mitchellii (Mitchell's satyr, federal/state endangered)
Orphulella pelidna (green desert grasshopper, state special concern)
Papaipema cerina (golden borer, state special concern)
Papaipema maritima (maritime sunflower borer, state special concern)
Papaipema speciosissima (regal fern borer, state special concern)
Sistrurus c. catenatus (eastern massasauga, federal candidate species and state special concern)
Spartiniphaga inops (spartina moth, state special concern)
Spiza americana (dickcissel, state special concern)
Tyto alba (barn owl, state endangered)

Biodiversity Management Considerations

The majority of wet-mesic prairie acreage was converted to agriculture following European settlement. Threats to remaining sites include hydrologic alteration, nutrient enrichment, siltation, fire suppression, tree and shrub encroachment, and destruction of upland buffers. Fire suppression and hydrologic alterations such as ditching and drain tiling promote shrub and tree invasion, which reduces graminoid cover and the fine fuels capable of carrying a fire. Invasive plants are favored by nutrient enrichment, fire suppression, and hydrologic alteration. Invasive species include glossy buckthorn (*Rhamnus frangula*), common buckthorn (*R. cathartica*), multiflora rose

(*Rosa multiflora*), autumn olive (*Elaeagnus umbellata*), reed (*Phragmites australis*), reed canary grass (*Phalaris arundinacea*), narrow-leaved cat-tail (*Typha angustifolia*), hybrid cat-tail (*T. xglauca*), and purple loosestrife (*Lythrum salicaria*). Prescribed fire, in conjunction with cutting and/or herbiciding of invasive species, should be considered to maintain the biodiversity of lowland grasslands. Some sites may require hydrologic restoration and efforts to restrict nutrient and sediment inputs. In addition, restoration of upland natural communities bordering wet prairie occurrences should be conducted to improve hydrology and provide refugia for flood-intolerant species during periods of high water.

Variation

Dominance varies among big bluestem, Indian grass, cordgrass, sedges, and native forbs. Some occurrences are associated with seasonal flooding, others apparently flood only rarely or not at all. Sites with bluejoint and/or cordgrass as dominants or subdominants may represent wet prairie. Occurrences associated with prairie fen show strong floristic influences of that community type, but wet-mesic prairies occupy mineral soil and prairie fens are found on organics soils.

Similar Natural Communities

Wet prairie, wet-mesic sand prairie, lakeplain wet-mesic prairie, lakeplain wet prairie, southern wet meadow, and prairie fen.

Relevant Literature

- Chapman, K.A. 1984. An ecological investigation of native grassland in southern Lower Michigan. M.A. thesis, Western Michigan University, Kalamazoo, MI. 235 pp.
- Galatowitsch, S.M., D.C. Whited, R. Lehtinen, J. Husveth, and K. Schik. 2000. The vegetation of wet meadows in relation to their land-use. *Environmental Monitoring and Assessment* 60: 121-144.
- Kercher, S.M., and J.B. Zedler. 2004a. Flood tolerance in wetland angiosperms: A comparison of invasive and noninvasive species. *Aquatic Botany* 80: 89-102.
- Kercher, S.M., and J.B. Zedler. 2004b. Multiple disturbances accelerate invasion of reed canary grass (*Phalaris arundinacea* L.) in a mesocosm study. *Oecologia* 138: 455-464.
- NatureServe. 2006. NatureServe Explorer: An online encyclopedia of life [Web application]. Version 6.1. NatureServe, Arlington, VA. Available <http://www.natureserve.org/explorer>. (Accessed: January 3, 2007.)

For a full list of references used to create this description, please refer to the natural community abstract for wet-mesic prairie.

Wet-mesic Sand Prairie

Global/State Rank: G2G3/S2

Overview

Wet-mesic sand prairie is a native lowland grassland occurring on sandy outwash plains and lakeplains within shallow depressions and as a vegetation zone separating fire-dependent upland and open wetland systems. The community occurs in the southern and northern Lower Peninsula on loamy sand or fine sand, usually with high organic content, and sometimes covered by a thin layer of muck. Sites that support wet-mesic sand prairie experience fluctuating water tables, with high water tables occurring in the spring followed by drought conditions in late summer and fall. Thus, the community contains species from a broad range of moisture classes, but is dominated by species of wetland affinity. Species dominance is shared by several prairie and wetland grasses and sedges. Historically, fire and beaver flooding played integral roles in maintaining the species composition and community structure of wet-mesic sand prairies.

Landscape Context

Wet-mesic sand prairie occurs on sandy sites with high water tables such as those occurring in shallow depressions within sandy outwash plains, lakeplains, old abandoned glacial lakebeds, stream channels, and river terraces. It often occurs as a vegetation zone between fire-dependent uplands and open wetlands such as dry or dry-mesic forests and coastal plain marsh or intermittent wetland. Wet-mesic sand prairie generally occurs as small isolated patches within a broader matrix of fire-dependent communities such as pine barrens, oak-pine barrens, oak barrens, and associated dry and dry-mesic forests and open wetland types including coastal plain marsh, intermittent wetland, and bog.

Soils

Soils are loamy sand, loamy fine sand, or fine sand and are typically strongly acid to neutral. Soils often have high organic content, which increases water-holding capacity, and may be covered by a thin layer of muck. A high water table contributes to the wet-mesic condition of the sandy soils.

Natural Processes

Water level fluctuations and fire help maintain diversity and open conditions. Wet-mesic sand prairie experiences seasonal water table fluctuations, with the wettest conditions occurring in spring and driest periods in late summer and fall. Prolonged winter and spring inundation may occur in the wettest portions of some wet-mesic sand prairies. Seasonal and annual water level fluctuations create conditions suitable for plant species representing a broad range of moisture tolerances. In addition, a seasonally high water table and periods of saturation or inundation limit encroachment by shrubs and trees. Beaver can reduce shrub and tree cover by causing flooding, raising local water tables, and through herbivory. Prior to European settlement in the early 1800s, fires of natural and anthropogenic origin likely carried into the community from surrounding uplands and further limited encroachment by shrubs and trees. Fire helps maintain species diversity by facilitating seed germination, opening microsites for seedling establishment and growth of small species, and releasing important plant nutrients that bolster plant growth, flowering, and seed set.

Vegetation

Species dominance varies among several prairie and wetland grasses and sedges, including bluejoint grass (*Calamagrostis canadensis*), cordgrass (*Spartina pectinata*), big bluestem (*Andropogon gerardii*), little bluestem (*Andropogon scoparius*), prairie dropseed (*Sporobolus heterolepis*), Indian grass (*Sorghastrum nutans*), and tussock sedge (*Carex stricta*). Shrubs are important in some occurrences, represented by tag alder (*Alnus rugosa*), black chokeberry (*Aronia prunifolia*), leatherleaf (*Chamaedaphne calyculata*), gray dogwood (*Cornus foemina*), red-osier dogwood (*C. stolonifera*), Kalm's St. John's-wort (*Hypericum kalmianum*), shrubby cinquefoil (*Potentilla fruticosa*), pasture rose (*Rosa carolina*), northern dewberry (*Rubus flagellaris*), swamp dewberry (*R. hispidus*), willows (*Salix* spp.), and meadowsweet (*Spiraea alba*). Trees are occasional or patchy, represented by species typical of the surrounding landscape. Characteristic herbs include ticklegrass (*Agrostis hyemalis*), harebell (*Campanula rotundifolia*), sedges (*Carex buxbaumii*, *C. flava*, *C. leptalea*, *C. pellita*, *C. pensylvanica*), swamp thistle (*Cirsium muticum*), bastard toadflax (*Comandra umbellata*), golden-seeded spike-rush (*Eleocharis elliptica*), grass-leaved goldenrod (*Euthamia graminifolia*), wild strawberry (*Fragaria virginiana*), fowl manna grass (*Glyceria striata*), blue flags (*Iris virginica* and *I. versicolor*), rushes (i.e., *Juncus balticus*, *J. effusus*, *J. greenii*, and *J. vaseyi*), cardinal flower (*Lobelia cardinalis*), pale spiked lobelia (*L. spicata*), common water horehound (*Lycopus americanus*), wild bergamot (*Monarda fistulosa*), northern panic grass (*Panicum boreale*), switch grass (*P. virgatum*), water smartweed (*Polygonum amphibium*), Virginia mountain mint (*Pycnanthemum virginianum*), wool-grass (*Scirpus cyperinus*), balsam ragwort (*Senecio pauperculus*), common blue-eyed-grass (*Sisyrinchium albidum*), late goldenrod (*Solidago gigantea*), rough goldenrod (*S. rugosa*), purple meadow rue (*Thalictrum dasycarpum*), marsh fern (*Thelypteris palustris*), marsh St. John's-wort (*Triadenum fraseri*), and white camas (*Zigadenus glaucus*). Invasive Canada bluegrass (*Poa compressa*) and Kentucky bluegrass (*P. pratensis*) are common in some sites.

Noteworthy Animals

Beaver (*Castor canadensis*) can cause flooding that substantially alters wetland community structure, converting lowland shrub and forest systems to a broad range of wetland types depending on landscape position, soils, and depth and duration of flooding.

Rare Plants

Asclepias hirtella (tall green milkweed, state threatened)
Carex tinctoria (sedge, state threatened)
Helianthus mollis (downy sunflower, state threatened)
Lactuca floridana (woodland lettuce, state threatened)
Oxalis violacea (violet wood-sorrel, presumed extirpated from Michigan)
Scirpus clintonii (Clinton's bulrush, state special concern)
Scleria triglomerata (tall nut-rush, state special concern)
Sisyrinchium strictum (blue-eyed-grass, state special concern)
Sporobolus heterolepis (prairie dropseed, state special concern)
Strophostyles helvula (trailing wild bean, state special concern)
Viola novae-angliae (New England violet, state threatened)

Rare Animals

Ammodramus henslowii (Henslow's sparrow, state endangered)
Ammodramus savannarum (grasshopper sparrow, state special concern)
Asio flammeus (short-eared owl, state endangered)
Atrytonopsis hianna (dusted skipper, state special concern)
Chlosyne gorgone carlota (Gorgone checkerspot, state special concern)

Chondestes grammacus (lark sparrow, state endangered)
Clemmys guttata (spotted turtle, state threatened)
Emydoidea blandingii (Blanding's turtle, state special concern)
Lanius ludovicianus migrans (migrant loggerhead shrike, state endangered)
Microtus ochrogaster (prairie vole, state endangered)
Pantherophis spiloides (gray ratsnake, state special concern)
Phyciodes batesii (tawny crescent, state special concern)
Pygarctia spraguei (Sprague's pygarctia, state special concern)
Schinia indiana (phlox moth, state endangered)
Sistrurus c. catenatus (eastern massasauga, federal candidate species and state special concern)
Speyeria idalia (regal fritillary, state endangered)
Spiza americana (dickcissel, state special concern)
Sturnella neglecta (western meadowlark, state special concern)
Terrapene c. carolina (eastern box turtle, state special concern)

Biodiversity Management Considerations

Threats to wet-mesic sand prairie include hydrologic alteration, fire suppression, tree and shrub encroachment, and destruction of upland buffers. Fire suppression and hydrologic alteration promote shrub and tree invasion, significantly reducing graminoid and sedge cover. Prescribed fire can be applied to restrict encroaching trees and shrubs, reduce litter build-up, and promote seed bank expression. Sites impacted by severe encroachment of tall shrubs and trees are likely to require an initial step of cutting and herbiciding woody stems to prevent resprouting and facilitate growth of the fine herbaceous fuels needed to carry a fire. Restoration of the upland natural communities bordering wet-mesic sand prairie occurrences will improve hydrology and help provide refugia for flood-intolerant species during periods of high water.

Monitoring and control efforts to detect and remove invasive species are critical to the long-term viability of wet-mesic sand prairie. Invasive species that threaten the diversity and community structure include glossy buckthorn (*Rhamnus frangula*), common buckthorn (*Rhamnus cathartica*), autumn olive (*Elaeagnus umbellata*), Eurasian honeysuckles (*Lonicera morrowii*, *L. japonica*, *L. maackii*, *L. sempervirens*, *L. tatarica*, *L. xbella*, and *L. xylosteum*), multiflora rose (*Rosa multiflora*), reed (*Phragmites australis*), reed canary grass (*Phalaris arundinacea*), narrow-leaved cat-tail (*Typha angustifolia*), hybrid cat-tail (*Typha xglauca*), and purple loosestrife (*Lythrum salicaria*).

Variation

Species composition varies regionally.

Similar Natural Communities

Mesic sand prairie, wet-mesic prairie, wet prairie, lakeplain wet-mesic prairie, and lakeplain wet prairie.

Relevant Literature

- Chapman, K.A. 1984. An ecological investigation of native grassland in southern Lower Michigan. M.A. thesis, Western Michigan University, Kalamazoo, MI.
- Faber-Langendoen, D., and P.F. Maycock. 1992. A vegetation analysis of tallgrass prairie in southern Ontario. Pp. 17-32 in Proceedings of the Thirteenth North American Prairie Conference: Spirit of the land, our prairie legacy, ed. R.G. Wickett, P.D. Lewis, A. Woodliffe. Department of Parks and Recreation, Windsor, Ontario, Canada. 262 pp.

Kost, M.A., and J.G. Cohen. 2005. A reassessment of high-quality natural communities on Camp Grayling. Report for Michigan Department of Military and Veterans Affairs, Camp Grayling, MI. Michigan Natural Features Inventory, Lansing, MI. 124 pp.

NatureServe. 2006. NatureServe Explorer: An online encyclopedia of life [Web application]. Version 6.1. NatureServe, Arlington, VA. Available <http://www.natureserve.org/explorer>. (Accessed: January 12, 2007.)

For a full list of references used to create this description, please refer to the natural community abstract for wet-mesic sand prairie.

Lakeplain Wet Prairie

Global/State Rank: G2?/S1

Overview

Lakeplain wet prairie is a species-rich prairie community that occurs on the seasonally wet ground of glacial lakeplains in the southern Great Lakes region. The community occurs along the shoreline of Lake Huron in Saginaw Bay, within the St. Clair River Delta, and near Lake Erie. Seasonal flooding, cyclic changes in Great Lakes water levels, beaver flooding, and fire historically maintained the species composition and community structure of lakeplain wet prairies.

Landscape Context

Lakeplain wet prairie occurs on level, sandy glacial lakeplains and deposits of dune sand in silt/clay glacial lakeplains. Historically, the mosaic of sand deposits and thin mineral soil on clay glacial lakeplains supported a patchwork of natural communities such as lakeplain wet prairie, lakeplain wet-mesic prairie, lakeplain oak openings, wet-mesic flatwoods, and southern hardwood swamps. Lakeplain wet prairie often occupies a transition zone between emergent marsh or Great Lakes marsh and lakeplain wet-mesic prairie.

Soils

Soils are medium- to fine-textured, slightly acid to moderately alkaline sands, sandy loams, or silty clays with poor to moderate water-retaining capacity.

Natural Processes

Lakeplain prairies typically experience seasonal flooding and include small pockets that remain wet throughout the year. Glacial lakeplains that support wet prairies often have a clay layer positioned below one to three meters of highly permeable sand. The clay layer both impedes drainage and prevents groundwater from moving to the surface, resulting in temporary flooding in the winter and spring and drought in summer and fall. Extreme variation in soil moisture regime limits establishment of woody vegetation. Vegetation composition and structure of lakeplain wet prairies are also affected by cyclic changes in Great Lakes water levels, which influence the regional water table.

Other factors that influence the development and maintenance of lakeplain wet prairies include beaver activity and periodic wildfire. Prolific beaver activity in the flat lakeplain landscape may have contributed to the extensive wet prairies that were known from pre-European settlement. The combination of accumulated organic material and drought conditions during the late growing season made lakeplain prairies prone to lightning- and Native American-induced wildfires.

Vegetation

The vegetation of lakeplain wet prairies is moderately dense with little exposed bare ground. Vegetation height averages one to two meters. The community is dominated by graminoids, but is extremely diverse, with as many as 200 plant species found within a single prairie remnant. Characteristic plants include bluejoint grass (*Calamagrostis canadensis*), cordgrass (*Spartina pectinata*), Baltic rush (*Juncus balticus*), sedges (*Carex stricta*, *Carex pellita*, and *C. aquatilis*), twig-rush (*Cladium mariscoides*), swamp milkweed (*Asclepias incarnata*), and shrubby cinquefoil (*Potentilla fruticosa*).

Noteworthy Animals

Beaver (*Castor canadensis*) can cause flooding that substantially alters wetland community structure, converting lowland shrub and forest systems to pond, emergent marsh, wet meadow, lakeplain wet prairie, and lakeplain wet-mesic prairie depending on landscape position, soils, and depth and duration of flooding.

Rare Plants

Agalinis gattingeri (Gattinger's gerardia, state endangered)
Agalinis skinneriana (Skinner's gerardia, state endangered)
Arabis missouriensis var. *deamii* (Missouri rock-cress, state special concern)
Aristida longespica (three-awned grass, state threatened)
Asclepias hirtella (tall green milkweed, state threatened)
Asclepias purpurascens (purple milkweed, state threatened)
Asclepias sullivantii (Sullivant's milkweed, state threatened)
Aster praealtus (willow aster, state special concern)
Cacalia plantaginea (prairie Indian-plantain, state special concern)
Carex festucacea (fescue sedge, state special concern)
Cypripedium candidum (white lady's-slipper, state threatened)
Eleocharis engelmannii (Engelmann's spike-rush, state special concern)
Fimbristylis puberula (chestnut sedge, presumed extirpated from Michigan)
Hypericum gentianoides (gentian-leaved St. John's-wort, state special concern)
Juncus vaseyi (Vasey's rush, state threatened)
Leucospora multifida (conobea, state special concern)
Lycopodiella margueriteae (northern prostrate clubmoss, state special concern)
Lycopodiella subappressa (northern appressed bog clubmoss, state special concern)
Mimulus alatus (wing-stemmed monkey-flower, presumed extirpated from Michigan)
Panicum polyanthes (round-seed panic grass, state endangered)
Platanthera leucophaea (prairie fringed orchid, federal threatened and state endangered)
Polygala cruciata (cross-leaved milkwort, state special concern)
Polygala incarnata (sand milkwort, state threatened)
Potentilla paradoxa (sand cinquefoil, state threatened)
Scirpus clintonii (Clinton's bulrush, state special concern)
Scleria pauciflora (few-flowered nut-rush, state endangered)
Scleria triglomerata (tall nut-rush, state special concern)
Sisyrinchium farwellii (Farwell's blue-eyed-grass, presumed extirpated from Michigan)

Rare Animals

Ammodramus savannarum (grasshopper sparrow, state special concern)
Asio flammeus (short-eared owl, state endangered)
Botaurus lentiginosus (American bittern, state special concern)
Circus cyaneus (northern harrier, state threatened)
Clemmys guttata (spotted turtle, state threatened)
Dorydiella kansana (leafhopper, state special concern)
Flexamia delongi (leafhopper, state special concern)
Flexamia reflexus (leafhopper, state special concern)
Gastrocopta holzingeri (lambda snaggletooth, endangered)
Neoconocephalus lyrists (bog conehead, state special concern)
Neoconocephalus retusus (conehead grasshopper, state special concern)
Orchelimum concinnum (red-faced meadow katydid, state special concern)
Orchelimum delicatum (delicate meadow katydid, state special concern)
Orphulella pelidna (green desert grasshopper, state special concern)

Papaipema beeriana (blazing star borer, state special concern)
Pantherophis gloydi (eastern fox snake, state threatened)
Phalaropus tricolor (Wilson's phalarope, state special concern)
Rallus elegans (king rail, state endangered)
Spiza americana (dickcissel, state special concern)
Tyto alba (barn owl, state endangered)

Biodiversity Management Considerations

Since the 1800s, there has been extensive loss and degradation of lakeplain wet prairies due to conversion to agriculture, residential and industrial development, alterations of groundwater hydrology, and fire suppression. It is estimated that less than 1% of the original community remains. Therefore, protection and restoration of existing prairie remnants is a top conservation priority.

Threats to remaining sites include hydrologic alteration, nutrient enrichment, siltation, fire suppression, shrub and tree encroachment, and destruction of upland buffers. Fire suppression and hydrologic alterations such as ditching and tiling promote shrub and tree invasion, which results in reduced cover of graminoids and the fine-fuels needed to carry a fire. Invasive plants are favored by nutrient enrichment, fire suppression, and hydrologic alteration. Invasive species that threaten the diversity and community structure of lakeplain wet prairie include glossy buckthorn (*Rhamnus frangula*), multiflora rose (*Rosa multiflora*), autumn olive (*Elaeagnus umbellata*), reed (*Phragmites australis*), reed canary grass (*Phalaris arundinacea*), narrow-leaved cat-tail (*Typha angustifolia*), hybrid cat-tail (*Typha xglauca*), and purple loosestrife (*Lythrum salicaria*). Prescribed fire, in conjunction with cutting and/or herbiciding of invasive species, can be used to maintain biodiversity of lowland grasslands. Some sites may require hydrologic restoration and efforts to restrict nutrient and sediment inputs. In addition, restoration of upland natural communities bordering lakeplain wet prairie occurrences should be conducted to improve hydrology and provide refugia for flood-intolerant species during periods of high water.

Variation

Species composition is influenced by depth and duration of seasonal flooding and proximity to other wetland communities.

Similar Natural Communities

Lakeplain wet-mesic prairie, wet prairie, wet-mesic prairie, wet-mesic sand prairie, southern wet meadow, Great Lakes marsh, and emergent marsh.

Relevant Literature

- Albert, D.A., D.L. Cuthrell, D.A. Hyde, J.T. Legge, M.R. Penskar, and M.L. Rabe. 1996. Sampling and management of lakeplain prairies in southern Lower Michigan. Michigan Natural Features Inventory, Lansing, MI. 93 pp.
- Albert, D.A., and M.A. Kost. 1998. Natural community abstract for lakeplain wet prairie. Michigan Natural Features Inventory, Lansing, MI. 4 pp.
- Comer, P.J., W.A. MacKinnon, M.L. Rabe, D.L. Cuthrell, M.R. Penskar, and D.A. Albert. 1995. A survey of lakeplain prairie in Michigan. Michigan Natural Features Inventory, Lansing, MI. 232 pp.
- Hayes, B.N. 1964. An ecological study of wet prairie on Harsens Island, Michigan. Michigan Botanist 3: 71-82.

- Faber-Langendoen, D., and P.F. Maycock. 1987. Composition and soil-environment analysis of prairies on Walpole Island, southwestern Ontario. *Canadian Journal of Botany* 65: 2410-2419.
- Jones, C.L., and R.O. Kapp. 1972. Relationship of Bay County Michigan presettlement forest patterns to Indian cultures. *Michigan Academician* 5: 17-28.
- Minc, L.D. 1995. Seasonal hydrology and species relationships in Lower Michigan's lakeplain prairies. An analysis and report submitted to Michigan Natural Features Inventory. 89 pp.

For a full list of references used to create this description, please refer to the natural community abstract for lakeplain wet prairie.

Lakeplain Wet-mesic Prairie

Global/State Rank: G1?/S1

Overview

Lakeplain wet-mesic prairie is a species-rich, lowland prairie community that occurs on moist, level, seasonally inundated glacial lakeplains of the Great Lakes. Seasonal flooding, cyclic changes in Great Lakes water levels, beaver flooding, and fire historically maintained the species composition and community structure of lakeplain wet-mesic prairies.

Landscape Context

Lakeplain wet-mesic prairie occurs on several glacial features of the lakeplain, including level, sandy outwash, sandy lakeplains, and deposits of dune sand on silt or clay glacial lakeplains. The community is most commonly associated with inland portions of lakeplains, but is also found along low beach ridges near the Saginaw Bay shoreline. Historically, these prairies occurred in a complex mosaic of lakeplain wet prairie, mesic sand prairie, lakeplain oak openings, wet-mesic flatwoods, and southern hardwood swamp.

Soils

Soils of this natural community are fine-textured, slightly acid to moderately alkaline sands, sandy loams, or silty clays with poor to moderate water-retaining capacity.

Natural Processes

Lakeplain prairies typically experience seasonal flooding and include small pockets that remain wet throughout the year. Glacial lakeplains that support wet-mesic prairies often have a clay layer positioned below one to three meters of highly permeable sand. The clay layer impedes drainage, resulting in temporary flooding in the winter and spring and drought in summer and fall. Extreme variation in soil moisture regime limits the establishment of woody vegetation. Lakeplain wet-mesic prairies are also affected by changes in Great Lakes water cycles that produce fluctuations in the water table.

Other factors that influence the development and maintenance of lakeplain wet-mesic prairies include beaver activity and periodic wildfire. Prolific beaver activity in the flat lakeplain landscape may have contributed to the extensive wet prairies that were known from pre-European settlement. The combination of accumulated organic material and drought conditions during the late growing season made lakeplain prairies prone to lightning- and Native American-induced wildfires.

Vegetation

The vegetation of lakeplain wet-mesic prairies is moderately dense with little exposed bare ground. Vegetation height averages one to two meters. The community is dominated by graminoids, but is extremely diverse, with as many as 200 plant species found within a single prairie remnant. Characteristic plants include big bluestem (*Andropogon gerardii*), sedge (*Carex* spp.), switch grass (*Panicum virgatum*), little bluestem (*Schizachyrium scoparium*), Indian grass (*Sorghastrum nutans*), Ohio goldenrod (*Solidago ohioensis*), Virginia mountain mint (*Pycnanthemum virginianum*), swamp betony (*Pedicularis lanceolata*), Riddell's goldenrod (*Solidago riddellii*), marsh blazing star (*Liatris spicata*), colic root (*Aletris farinosa*), and tall coreopsis (*Coreopsis tripteris*) and ironweed (*Vernonia* spp.).

Noteworthy Animals

Beaver (*Castor canadensis*) can cause flooding that substantially alters wetland community structure, converting lowland shrub and forest systems to pond, emergent marsh, wet meadow, lakeplain wet prairie, and lakeplain wet-mesic prairie depending on landscape position, soils, and depth and duration of flooding.

Rare Plants

Asclepias hirtella (tall green milkweed, state threatened)
Asclepias purpurascens (purple milkweed, state threatened)
Asclepias sullivantii (Sullivant's milkweed, state threatened)
Bartonia paniculata (panicled screw-stem, state threatened)
Betula populifolia (gray birch, state special concern)
Eleocharis tricostata (three-ribbed spike-rush, state threatened)
Juncus brachycarpus (short-fruited rush, state threatened)
Juncus vaseyi (Vasey's rush, state threatened)
Lactuca floridana (woodland lettuce, state threatened)
Lechea pulchella (Leggett's pinweed, state threatened)
Lycopodiella margueriteae (northern prostrate clubmoss, state special concern)
Lycopodiella subappressa (northern appressed bog clubmoss, state special concern)
Mimulus alatus (wing-stemmed monkey-flower, presumed extirpated from Michigan)
Oxalis violacea (violet wood-sorrel, presumed extirpated from Michigan)
Panicum longifolium (long-leaved panic-grass, state threatened)
Platanthera leucophaea (prairie fringed orchid, federal threatened and state endangered)
Potentilla paradoxa (sand cinquefoil, state threatened)
Rhexia mariana var. *mariana* (Maryland meadow beauty, state special concern)
Rhexia virginica (meadow beauty, state special concern)
Rhynchospora macrostachya (tall beak-rush, state special concern)
Scleria pauciflora (few-flowered nut-rush, state endangered)
Scleria reticularis (netted nut-rush, state threatened)
Scleria triglomerata (tall nut-rush, state special concern)
Sisyrinchium atlanticum (Atlantic blue-eyed-grass, state threatened)
Sisyrinchium farwellii (Farwell's blue-eyed-grass, presumed extirpated from Michigan)

Rare Animals

Ammodramus henslowii (Henslow's sparrow, state endangered)
Ammodramus savannarum (grasshopper sparrow, state special concern)
Asio flammeus (short-eared owl, state endangered)
Botaurus lentiginosus (American bittern, state special concern)
Circus cyaneus (northern harrier, state threatened)
Clemmys guttata (spotted turtle, state threatened)
Dorydiella kansana (leafhopper, state special concern)
Flexamia delongi (leafhopper, state special concern)
Flexamia reflexus (leafhopper, state special concern)
Gastrocopta holzingeri (lambda snaggletooth, endangered)
Neoconocephalus lyrists (bog conehead, state special concern)
Neoconocephalus retusus (conehead grasshopper, state special concern)
Orchelimum concinnum (red-faced meadow katydid, state special concern)
Orchelimum delicatum (delicate meadow katydid, state special concern)
Orphulella pelidna (green desert grasshopper, state special concern)
Pantherophis gloydi (eastern fox snake, state threatened)
Papaipema beeriana (blazing star borer, state special concern)

Phalaropus tricolor (Wilson's phalarope, state special concern)
Rallus elegans (king rail, state endangered)
Spiza americana (dickcissel, state special concern)
Tyto alba (barn owl, state endangered)

Biodiversity Management Considerations

Since European settlement, there has been extensive loss and degradation of lakeplain wet-mesic prairies due to conversion to agriculture, residential and industrial development, alterations of groundwater hydrology, and fire suppression. It is estimated that less than 1% of the original community remains. Therefore, protection and restoration of existing prairie remnants is a top conservation priority.

Threats to remaining sites include hydrologic alteration, nutrient enrichment, siltation, fire suppression, tree and shrub encroachment, and destruction of upland buffers. Fire suppression and hydrologic alterations such as ditching and drain tiling promote shrub and tree invasion, which reduces graminoid cover and the fine fuels capable of carrying a fire. Invasive plants are favored by nutrient enrichment, fire suppression, and hydrologic alteration. Invasive species that threaten the diversity and community structure in lakeplain wet-mesic prairie include glossy buckthorn (*Rhamnus frangula*), common buckthorn (*R. cathartica*), multiflora rose (*Rosa multiflora*), autumn olive (*Elaeagnus umbellata*), reed (*Phragmites australis*), reed canary grass (*Phalaris arundinacea*), narrow-leaved cat-tail (*Typha angustifolia*), hybrid cat-tail (*Typha xglauca*), and purple loosestrife (*Lythrum salicaria*). Prescribed fire, in conjunction with cutting and/or herbiciding of invasive species, should be considered to maintain the biodiversity of lowland grasslands. Some sites may require hydrologic restoration and efforts to restrict nutrient and sediment inputs. In addition, restoration of upland natural communities bordering lakeplain wet-mesic prairie occurrences should be conducted to improve hydrology and provide refugia for flood-intolerant species during periods of high water.

Variation

The difference in characteristic flora and fauna between coastal and inland occurrences of lakeplain wet-mesic prairie needs further description and assessment.

Similar Natural Communities

Lakeplain wet prairie, wet-mesic prairie, wet-mesic sand prairie, mesic sand prairie, and mesic prairie.

Relevant Literature

- Albert, D.A., and M.A. Kost. 1998. Natural community abstract for lakeplain wet-mesic prairie. Michigan Natural Features Inventory, Lansing, MI. 4 pp.
- Albert, D.A., D.L. Cuthrell, D.A. Hyde, J.T. Legge, M.R. Penskar, and M.L. Rabe. 1996. Sampling and management of lakeplain prairies in southern Lower Michigan. Michigan Natural Features Inventory, Lansing, MI. 93 pp.
- Bakowsky, W., and J.L. Riley. 1992. A survey of the prairies and savannas of southern Ontario. Pp. 7-16 in Proceedings of the Thirteenth North American Prairie Conference: Spirit of the land, our prairie legacy, ed. R.G. Wickett, P.D. Lewis, A. Woodliffe, and P. Pratt. Department of Parks and Recreation, Windsor, Ontario, Canada. 262 pp.
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- Hubbard, B. 1888. *Memorials of a half-century in Michigan and the Lake Region*. G.P. Putnam's Sons. Pp. 360-367.
- Jones, C.L., and R.O. Kapp. 1972. Relationship of Bay County Michigan presettlement forest patterns to Indian cultures. *Michigan Academician* 5: 17-28.
- Minc, L.D. 1995. Seasonal hydrology and species relationships in Lower Michigan's lakeplain prairies. An analysis and report submitted to Michigan Natural Features Inventory. 89 pp.
- Roberts, T.M., T. Robson, and P.J. Catling. 1977. Factors maintaining a disjunct community of *Liatris spicata* and other prairie species in Ontario, Canada. *Canadian Journal of Botany* 55: 593-605.
- Rogers, C.M. 1966. A wet prairie community at Windsor, Ontario. *Canadian Field Naturalist* 80: 195-199.

For a full list of references used to create this description, please refer to the natural community abstract for lakeplain wet-mesic prairie.

FEN COMMUNITIES

Prairie Fen

Global/State Rank: G3/S3

Overview

Prairie fen is a wetland community dominated by sedges, grasses, and other graminoids that occurs on moderately alkaline organic soil and marl south of the climatic tension zone in southern Lower Michigan. Prairie fens occur where cold, calcareous, groundwater-fed springs reach the surface. The flow rate and volume of groundwater through a fen strongly influence vegetation patterning; thus, the community typically contains multiple, distinct zones of vegetation, some of which contain prairie grasses and forbs.

Landscape Context

Prairie fens occur predominantly within poorly drained outwash channels and outwash plains in the interlobate regions of southern Lower Michigan. This area is comprised of coarse-textured end moraines and ice-contact features (eskers and kames) that are bordered by glacial outwash. Prairie fen often occurs where an outwash feature (channel or plain) abuts a coarse-textured end moraine or ice-contact feature.

Historically, the uplands surrounding prairie fens typically supported fire-dependent oak barrens and oak openings. Today, most of the surrounding uplands support closed-canopy oak forest (dry and dry-mesic southern forest), agriculture, or rural residential development.

Prairie fens typically occur as part of large wetland complexes that support a variety of wetland communities including emergent marsh, southern wet meadow, wet prairie, wet-mesic prairie, southern shrub-carr, and rich tamarack swamp. The community is frequently found along both small lakes and the upper reaches of streams and rivers.

Soils

Prairie fen occurs on saturated organic soil and marl, a calcium carbonate (CaCO_3) precipitate. Marl deposits can accumulate to depths greater than one meter in lakes and shallow calcareous water as a result of metabolism by algae. The organic soils are typically mildly alkaline, with marl deposits reaching slightly higher levels of alkalinity. The soil profile of prairie fens often contains distinct zones of sedge peat, woody peat, and marl. Thus, the organic deposits may change with depth throughout the soil profile from fibric peat to hemic peat or well-decomposed sapric peat (muck) depending on a fen's successional history and past disturbance regime. The white- to grayish-colored marl may be present as discrete, sometimes thick, bands within the soil profile or at the surface, where it may occupy small pools surrounding groundwater springs, or cover extensive portions of a fen.

Natural Processes

The groundwater that supports the hydrology of prairie fens is rich in calcium and magnesium carbonates, which are absorbed from the calcareous sand and gravel substrates of the surrounding glacial deposits. Prairie fens occur where cold, calcareous groundwater flows through the community's organic soil and reaches the surface in the form of perennial springs and seeps. The constant flow of groundwater from springs and seeps can result in the formation of small rivulets

that join to form headwater streams, or sheet flows that cover the soil surface with a thin layer of moving water. The substrate around springs and under areas of sheet flow is typically marl, which forms as a result of the metabolic activity of algae growing in water rich in calcium and magnesium carbonates (i.e., hard water). A steady flow of cold, calcareous groundwater also flows beneath the surface through the organic soil of prairie fens. Because the soils remain saturated throughout the year, aerobic bacteria that break down plant materials are much reduced, resulting in the buildup of partially decayed plant debris or peat. The buildup of organic matter around springs and seeps allows some prairie fen complexes to support both areas of “domed fen,” which appear as broad, round hills comprised of organic soils in the middle of the wetland, and “hanging fen,” which occur as low-gradient slopes of organic soil that can span from the upland edge across the wetland to meet level vegetation zones such as sedge meadow or marl flat. Both the domed fen and hanging fen can puzzle observers who are not accustomed to seeing wetlands occurring as hills and sloping terrains. In some locations, the large volume of water underlying prairie fens creates a quaking mat or floating mat, which shakes and reverberates with each step. Quaking mats are especially common where prairie fens occupy former lake basins that have filled with marl or peat. These “basin fens” may occupy the entire basin of an abandoned glacial lake or occupy portions of a basin along the shores of existing lakes.

Historically, fires moving across oak savanna (i.e., oak barrens and oak openings) routinely carried into bordering prairie fens. Most plants found within prairie fens are well adapted to fire. By consuming dried leaves from the previous growing season, fire increases the availability of important plant nutrients and reduces the thickness of the duff layer. The resulting reduction in litter allows light to reach the soil surface where it stimulates seed germination. Fire also facilitates seedling establishment by reducing competition from robust perennials, especially during the early growing season. The increased nutrient availability contributes to enhanced growth and bolsters flowering and seed set. By killing or top-killing shrubs and trees, fires help maintain the open and semi-open structure on which many of the community’s plants and animals depend. In summary, fire is an important ecological process for prairie fen as it facilitates nutrient cycling, seed bank expression and maintenance, and helps maintain community structure.

Historically, flooding resulting from beaver dams was very likely a common occurrence in the level and lower-elevation portions of prairie fen complexes. Prolonged flooding can kill trees, shrubs, and many herbaceous plants and results in conversion of prairie fen to shallow ponds, emergent marsh, or southern wet meadow.

Vegetation

Prairie fens typically contain several distinct vegetation zones, which may include inundated flat, sedge meadow, marl flat, and wooded fen. The vegetation zones correspond to differing levels of groundwater influence, water chemistry, organic or marl accumulation, and past natural and anthropogenic disturbances. Not all vegetation zones occur in all prairies fens.

Inundated flat can occur in low, level areas and near the margins of streams and lakes. Dominant species in this zone include hardstem bulrush (*Scirpus acutus*), three-square (*Schoenoplectus pungens*), lake sedge (*Carex lacustris*), water sedge (*C. aquatilis*), broad-leaved cat-tail (*Typha latifolia*), and common arrowhead (*Sagittaria latifolia*).

Sedge meadow is typically the largest vegetative zone of a prairie fen and is dominated by sedges, grasses, forbs, and low shrubs. The sedge meadow zone may occur in low, level areas and on slopes as hanging fen or domed fen, where it often assumes a shorter stature overall. Characteristic sedges include tussock sedge (*Carex stricta*), dioecious sedge (*C. sterilis*), wiregrass sedge (*C. lasiocarpa*), Bauxbaum's sedge (*C. buxbaumii*), prairie sedge (*C. prairea*),

and lesser paniced sedge (*C. diandra*). Common grasses include big bluestem (*Andropogon gerardii*), little bluestem (*A. scoparia*), Indian grass (*Sorghastrum nutans*), marsh wild-timothy (*Muhlenbergia glomerata*), fringed brome (*Bromus ciliatus*), bluejoint grass (*Calamagrostis canadensis*), and slender wheat grass (*Agropyron trachycaulum*). Common forbs include joe-pye-weed (*Eupatorium maculatum*), common boneset (*E. perfoliatum*), smooth swamp aster (*Aster firmus*), tall flat-top white aster (*A. umbellatus*), side-flowering aster (*A. lateriflorus*), swamp aster (*A. puniceus*), whorled loosestrife (*Lysimachia quadriflora*), Virginia mountain mint (*Pycnanthemum virginianum*), black-eyed Susan (*Rudbeckia hirta*), Ohio goldenrod (*Solidago ohioensis*), Riddell's goldenrod (*S. riddellii*), bog goldenrod (*S. uliginosa*), sensitive fern (*Onoclea sensibilis*), and marsh fern (*Thelypteris palustris*). Low shrubs occurring within the sedge meadow zone include shrubby cinquefoil (*Potentilla fruticosa*), alder-leaved buckthorn (*Rhamnus alnifolia*), sage willow (*Salix candida*), meadowsweet (*Spiraea alba*), and bog birch (*Betula pumila*). Scattered tall shrubs and trees may also occur, especially poison sumac (*Toxicodendron vernix*) and tamarack (*Larix laricina*).

Marl flats are distinct features of fens, forming in areas of calcareous groundwater seepage. They may occur as small pools or extensive, level areas occupying the basins of former lakes. In the latter, low peat ridges that support sphagnum mosses (*Sphagnum* spp.), pitcher-plant (*Sarracenia purpurea*), and stunted tamarack may be interspersed throughout the broad flats. Because the alkaline conditions permit few species to survive, marl flats are sparsely vegetated. Species occurring within marl flats include sedges (*Carex flava*, *C. leptalea*, and *C. sterilis*), Kalm's lobelia (*Lobelia kalmii*), grass-of-Parnassus (*Parnassia glauca*), beak-rushes (*Rhynchospora alba* and *R. capillacea*), common bog arrow-grass (*Triglochin maritimum*), twig-rush (*Cladium mariscoides*), rush (*Juncus brachycephalus*), golden-seeded spike-rush (*Eleocharis elliptica*), beaked spike-rush (*Eleocharis rostellata*), white lady's-slipper (*Cypripedium candidum*, state threatened), white camas (*Zigadenus glaucus*), and carnivorous plants such as round-leaved sundew (*Drosera rotundifolia*), pitcher-plant, flat-leaved bladderwort (*Utricularia intermedia*), and horned bladderwort (*U. cornuta*).

The wooded fen zone represents portions of the fen that are slowly succeeding to closed-canopy communities such as southern shrub-carr and rich tamarack swamp in the absence of management or natural disturbance. Many of the herbaceous species from the other vegetation zones also occur within wooded fen. Woody species occurring in this zone include poison sumac, bog birch, tamarack, silky dogwood (*Cornus amomum*), gray dogwood (*C. foemina*), red-osier dogwood (*C. stolonifera*), winterberry (*Ilex verticillata*), ninebark (*Physocarpus opulifolius*), nannyberry (*Viburnum lentago*), yellow birch (*Betula alleghaniensis*), red maple (*Acer rubrum*), and American elm (*Ulmus americana*). The wooded fen zone in most of the remaining prairie fens occupies a significantly greater area today than in the past due to the absence of fire and beaver flooding.

Noteworthy Animals

Ant mounds reaching more than half a meter in height and one meter in width are a common feature within the sedge meadow zone and where woody species have recently colonized open fen.

Rare Plants

Asclepias purpurascens (purple milkweed, state threatened)
Aster praealtus (willow aster, state special concern)
Berula erecta (cut-leaved water-parsnip, state threatened)
Cacalia plantaginea (prairie Indian-plantain, state special concern)
Calamagrostis stricta (narrow-leaved reedgrass, state threatened)

Carex richardsonii (Richardson's sedge, state threatened)
Cypripedium candidum (white lady's-slipper, state threatened)
Dodecatheon meadia (shooting star, state endangered)
Drosera anglica (English sundew, state threatened)
Eryngium yuccifolium (rattlesnake-master, state threatened)
Filipendula rubra (queen-of-the-prairie, state threatened)
Helianthus hirsutus (whiskered sunflower, state special concern)
Myrica pensylvanica (northern bayberry, state threatened)
Muhlenbergia richardsonis (mat muhly, state threatened)
Phlox maculata (wild sweet william, state threatened)
Polemonium reptans (Jacob's ladder, state threatened)
Pycnanthemum muticum (broad-leaved mountain mint, state threatened)
Sanguisorba canadensis (Canadian burnet, state endangered)
Sporobolus heterolepis (prairie dropseed, state special concern)
Valeriana edulis var. *ciliata* (edible valerian, state threatened)

Rare Animals

Acris blanchardi (Blanchard's cricket frog, state threatened)
Calephelis muticum (swamp metalmark, state special concern)
Clemmys guttata (spotted turtle, state threatened)
Clonophis kirtlandii (Kirtland's snake, state endangered)
Dorydiella kansana (leafhopper, state special concern)
Emydoidea blandingii (Blanding's turtle, state special concern)
Flexamia huroni (Huron River leafhopper, state threatened)
Lepyronia angulifera (angular spittlebug, state special concern)
Neonympha m. mitchellii (Mitchell's satyr, federal/state endangered)
Oarisma poweshiek (Poweshiek skipper, state threatened)
Oecanthus laricis (tamarack tree cricket, state special concern)
Papaipema beeriana (blazing star borer, state special concern)
Papaipema sciata (Culver's root borer, state special concern)
Papaipema silphii (silphium borer moth, state threatened)
Papaipema speciosissima (regal fern borer, state special concern)
Prosapia ignipectus (red-legged spittlebug, state special concern)
Sistrurus c. catenatus (eastern massasauga, federal candidate species and state threatened)
Terrapene c. carolina (eastern box turtle, state special concern)

Biodiversity Management Considerations

Land use planning to protect groundwater reserves in areas surrounding prairie fens is critical to maintaining the natural community. Drainage ditches can interrupt groundwater flow through fens, reducing water levels and facilitating rapid establishment and growth of shrubs and trees. Nutrient additions from leaking septic tanks, drain fields, or agricultural runoff can contribute to dominance by invasive species such as reed (*Phragmites australis*), reed canary grass (*Phalaris arundinacea*), and narrow-leaved cat-tail (*Typha angustifolia*).

Today, most prairie fens are significantly reduced in size as a result of shrub and tree establishment. In addition, the surrounding uplands have also changed from open, oak savanna or woodland, to closed-canopy forest. Historically, the principal natural process that maintained the open structure of these upland and wetland communities was fire. Thus, reintroducing fire through prescription burning of prairie fens and adjacent upland oak forests is a critical management need. Because of the small and fragmented condition of many of our remaining prairie fens, use of prescribed fire as a management tool should include setting aside significant

portions of fen to remain unburned in any given year to help lessen impacts to fire-sensitive species. Streams, rivers, lakes, and wet lines created by hoses can serve as fire breaks for establishing unburned refugia within a prairie fen.

In addition to prescribed fire, reducing the density of trees and shrubs also typically requires the use of herbicides, which can be applied to the recently cut stumps of woody plants. Cutting woody plants without applying herbicides is typically ineffective at reducing shrub and tree density because the plants resprout and grow rapidly from well developed root stocks.

Invasive species that reduce diversity and alter community structure in prairie fen include reed, reed canary grass, narrow-leaved cat-tail, hybrid cat-tail (*Typha xglauca*), purple loosestrife (*Lythrum salicaria*), European marsh thistle (*Cirsium palustre*), glossy buckthorn (*Rhamnus frangula*), common buckthorn (*R. cathartica*), multiflora rose (*Rosa multiflora*), and autumn olive (*Elaeagnus umbellata*). Glossy buckthorn, an invasive shrub, has become especially widespread and well established in prairie fens, where it has formed dense monocultures, replacing formerly species-rich open fen. Invasive species can spread rapidly and outcompete native plants for nutrients, light, and space. Reducing well established populations of invasive plants typically requires long-term commitments by managers to repeatedly apply control treatments, over multiple years, and carryout sustained monitoring efforts. The use of herbicides in controlling invasive species can be very effective, while cultural treatments such as pulling, mowing, and cutting by themselves generally have poor results.

Variation

Because of their proximity to the range of prairie in North America, prairie fens occurring in far southwestern Lower Michigan generally have a greater abundance and diversity of species associated with prairies than those located farther north and east.

Prairie fens can differ significantly in appearance from one another based on amount of groundwater input and water chemistry, disturbance history, proximity to streams or lakes, and position related to local landforms (outwash channels, moraines, etc.). Fens with extensive marl flats often develop on former glacial lakebeds (i.e., basin fens) and contain low, acidic peat mounds that support species associated with bogs. Domed fens occur where the buildup of organic soils around groundwater discharge areas has resulted in the creation of a large, low broad hill within the wetland. The broad peat domes usually support low vegetation associated with the sedge meadow zone. Hanging fens are often associated with the edges of moraines, eskers, and kames and appear as low gradient slopes along the edges of the upland. Hanging fens typically slope from the edges of the upland to level marl flats or stream channels and support low vegetation associated with the sedge meadow zone. Quaking mats are common features of prairie fens and are typically associated with springs, the edges of lakes, or basins of former glacial lakes that have filled with peat (i.e., basin fens). Quaking mats form as fen sedges creep out into open water or emergent or submergent marshes along the edges of lakes. Vegetation is typically low and dominated by sedges.

Similar Natural Communities

Northern fen, southern wet meadow, emergent marsh, coastal fen, poor fen, southern shrub-carr, wet prairie, wet-mesic prairie, and rich tamarack swamp.

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For a full list of references used to create this description, please refer to the natural community abstract for prairie fen.

Northern Fen

Global/State Rank: G3G5/S3

Overview

Northern fen is a sedge- and rush-dominated wetland occurring on neutral to moderately alkaline saturated peat and/or marl influenced by groundwater rich in calcium and magnesium carbonates. The community occurs north of the climatic tension zone and is found primarily where calcareous bedrock underlies a thin mantle of glacial drift on flat areas or shallow depressions of glacial outwash and glacial lakeplains and also in kettle depressions on pitted outwash and moraines.

Landscape Context

Northern fens occur on flat areas or shallow depressions of glacial outwash and glacial lakeplains, often in proximity to the Great Lakes shoreline, and also in kettle depressions on pitted outwash and moraines. Within outwash channels, fens are typically found where a constant flow of cold, calcareous groundwater seeps from the base of adjacent moraines. The overall topography of fens is flat to gently undulating with microtopography characterized by hummocks and hollows. Within kettle depressions, fens can occupy the entire basin or frequently occur as a floating mat on the margin of the remaining glacial lake. Fens occurring on former glacial lakebeds and drainageways tend to be more extensive than kettle fens, which are limited in area by the size of the glacial ice-block that formed the basin. Northern fens occurring on glacial outwash and glacial lakeplains occur on sapric to fibric peat or marly flats overlaying calcareous bedrock, typically dolomite or limestone of Devonian age. Northern fens often occur within large wetland complexes, where they grade into other wetland communities such as poor fen, northern wet meadow, northern shrub thicket, and rich conifer swamp.

Soils

The organic soils of northern fens are composed of peat and/or marl, which are typically one to three meters deep. The surface peats may range from sapric to fibric, and like the surface water, are neutral to alkaline and characterized by high cation availability. Northern fens are minerotrophic peatlands, receiving constant inputs of cold groundwater that is rich in calcium and magnesium carbonates from having moved over or percolated through base-rich bedrock or calcareous glacial deposits. Because groundwater is the primary source of water input, the hydro-period of fens is relatively stable; the soils remain saturated throughout the year but are seldom inundated by more than a few centimeters of water. Northern fens often contain or develop on extensive areas of marl, a grayish, mineral substrate with a smooth, silty texture that develops when metabolism by algae results in precipitation of calcium carbonate. Areas containing marl deposits such as old glacial lakebeds are level and referred to as marl flats. Shallow water supporting populations of marl-producing algae commonly overlays marl flats. Dispersed throughout extensive areas of marl flats are low peat mounds or islands that support a continuous carpet of sphagnum mosses and a full complement of bog and poor conifer swamp species. The pH of peat islands is extremely acidic as a result of the reducing effect of sphagnum mosses and raised elevation above the underlying calcareous groundwater.

Natural Processes

Saturated and inundated conditions inhibit organic matter decomposition and allow for the accumulation of peat. Development and expansion of fens occur via two different processes in glacial lakeplain and outwash versus kettle depressions. Fens develop in glacial lakeplain and outwash where groundwater influence maintains the saturated conditions that inhibit organic

matter decomposition and allows for peat accumulation. Peat develops vertically and spreads horizontally. Lake-filling occurs in small kettle lakes with minimal wave action where gradual peat accumulation results in the development of a sedge mat that can fill the basin or occur as a floating mat within the lake or as a grounded mat along the water's edge. Floating mats of fen sedges such as wiregrass sedge (*Carex lasiocarpa*) are able to pioneer open water and emergent marsh. The interlacing of rhizomes and roots forms a floating mat that is buoyed by water and accumulates organic matter in the form of sapric peat. Over time, fen mats are often invaded by ericaceous shrubs and acidifying sphagnum mosses. The invasion of sphagnum mosses into fen systems often results in the conversion of fens to more acidic communities such as poor fen or bog.

Extensive marl flats form through accumulation of marl on the bottom of hardwater lakes or former shallow embayments of the Great Lakes. Marl can build up and fill entire lake basins and shallow embayments, eventually becoming sparsely vegetated by a unique suite of species able to survive in alkaline conditions.

Natural disturbance factors influencing northern fens include constant saturation by cold, calcareous groundwater, fire, flooding, windthrow, and outbreaks of tree parasites and insects. Open conditions within fens are maintained primarily by hydrologic and chemical conditions that limit the establishment and growth of woody plants. Surface fires can contribute to the maintenance of fens by killing encroaching trees and shrubs without removing the peat, which is normally saturated. In the absence of fire, a thick layer of leaf litter can develop, which stifles seed bank expression and seedling establishment. Fire severity and frequency in fens is closely related to fluctuations in water level and landscape context; fens bordering fire-prone pine and oak-pine systems likely experienced occasional fires, whereas those embedded within rich conifer swamps or mesic northern forests burned very infrequently. Prolonged periods of lowered water table can allow the surface peat to dry out sufficiently to burn. Such peat fires can result in the conversion of peatland to mineral soil wetland. Peat fires within bogs can also release enough nutrients to favor succession to more minerotrophic peatlands such as northern fen or intermittent wetland. Lowering of the water table of fens results in the increase in decomposition rates of organic matter and the subsequent accumulation of compact peat that is more conducive to shrub and tree growth. In such a circumstance, northern fen can succeed to rich conifer swamp or northern shrub thicket. Flooding, often caused by beaver activity, can contribute to the maintenance of fens or result in the conversion of fens to bogs. Roots of trees in peatlands are physiologically active near the surface and are killed during prolonged flooding. Trees growing in fens are particularly susceptible to windthrow because peat provides a poor substrate for anchoring trees. Tree survival in fens is also limited by insects and parasites. Insect outbreaks of the larch sawfly (*Pristiphora erichsonii*) and larch casebearer (*Coleophora laricella*) cause heavy mortality of tamarack (*Larix laricina*), while the plant parasite dwarf mistletoe (*Arceuthobium pusillum*) kills black spruce (*Picea mariana*).

Vegetation

Northern fens are characterized by a unique and diverse calcicolous, heliophilous (sun-loving) flora with a rich herbaceous layer dominated by graminoids, and a patchy to continuous moss carpet, with brown mosses (*Amblystegiaceae*) more prevalent than sphagnum mosses (*Sphagnaceae*). While most fen plants are adapted to growing in alkaline conditions (i.e., calcicolous species), the vegetation assemblage growing on the isolated, low peat mounds resembles an ombrotrophic peatland system, with a continuous carpet of sphagnum mosses, low ericaceous, evergreen shrubs, and widely scattered or clumped, stunted conifer trees. Sedges dominate the herbaceous layer of fens. The most prevalent species in northern fens is wiregrass sedge (*Carex lasiocarpa*), which can form extensive lawns. Other sedges that are characteristic of

northern fens include water sedge (*C. aquatilis*), creeping sedge (*C. chordorrhiza*), bristly-stalked sedge (*C. leptalea*), mud sedge (*C. limosa*), livid sedge (*C. livida*), and dioecious sedge (*C. sterilis*). Typical grasses occurring in northern fen include bluejoint grass (*Calamagrostis canadensis*), reedgrass (*C. stricta*), hair grass (*Deschampsia cespitosa*), marsh wild-timothy (*Muhlenbergia glomerata*), and panic grass (*Panicum lindheimeri*). Additional graminoids that thrive in the calcareous environment of northern fens include twig-rush (*Cladium mariscoides*), three-way sedge (*Dulichium arundinaceum*), spike-rushes (*Eleocharis* spp.), sheathed cotton-grass (*Eriophorum spissum*), white beak-rush (*Rhynchospora alba*), and bulrushes (*Scirpus* spp.). The following is a list of prevalent northern fen forbs: rush aster (*Aster borealis*), marsh bellflower (*Campanula aparinoides*), swamp loosestrife (*Decodon verticillatus*), grass-leaved goldenrod (*Euthamia graminifolia*), wild blue flag (*Iris versicolor*), Kalm's lobelia (*Lobelia kalmii*), northern bugleweed (*Lycopus uniflorus*), swamp candles (*Lysimachia terrestris*), bog buckbean (*Menyanthes trifoliata*), grass-of-Parnassus (*Parnassia glauca*), silverweed (*Potentilla anserina*), marsh cinquefoil (*P. palustris*), Ohio goldenrod (*Solidago ohioensis*), bog goldenrod (*S. uliginosa*), false asphodel (*Tofieldia glutinosa*), marsh St. John's-wort (*Triadenum fraseri*), and common bog arrow-grass (*Triglochin maritimum*). The low shrub layer is usually less than one meter high with shrubby cinquefoil (*Potentilla fruticosa*), sweet gale (*Myrica gale*), and bog birch (*Betula pumila*) often being the most prevalent species. Other important associates of the low shrub layer include Kalm's St. John's-wort (*Hypericum kalmianum*), alder-leaved buckthorn (*Rhamnus alnifolia*), bog willow (*Salix pedicellaris*), and meadowsweet (*Spiraea alba*). The following are common heath shrubs of northern fens that occur on low peat mounds: bog rosemary (*Andromeda glaucophylla*), leatherleaf (*Chamaedaphne calyculata*), Labrador tea (*Ledum groenlandicum*), bog laurel (*Kalmia polifolia*), and small cranberry (*Vaccinium oxycoccos*). The tall shrub layer of northern fens, typically one to three meters tall, is often restricted to the periphery of the fen. Tall shrubs typical of northern fens include tag alder (*Alnus rugosa*), red-osier dogwood (*Cornus stolonifera*), slender willow (*Salix petiolaris*), bog birch and meadowsweet. Trees within fens are widely scattered, often occurring in clumps on low peat mounds, and are typically of low stature. Tree cover is typically below 10%. The most common dominants of the open canopy are tamarack (*Larix laricina*), northern white-cedar (*Thuja occidentalis*), and occasionally black spruce (*Picea mariana*).

Vegetational zones that frequently occur within northern fens include sedge lawns, sparsely vegetated marl flats, shrub thickets, which often occur as narrow bands on the upland margin, and low peat mounds dominated by sphagnum mosses, ericaceous shrubs, and scattered clumps of coniferous trees. Marl flats support a sparse vegetative cover of twig-rush, beak-rushes, spike-rushes, rushes, sedges, bulrushes, and forbs, which include silverweed, false asphodel, arrow-grass (*Scheuchzeria palustris*), grass-of-Parnassus, Kalm's lobelia, Ohio goldenrod, and stunted, misshapen, northern white-cedar.

Noteworthy Animals

Northern fens provide important habitat for small mammals such as short-tailed shrew (*Blarina brevicauda*), beaver (*Castor canadensis*), meadow vole (*Microtus pennsylvanicus*), mink (*Mustela vison*), muskrat (*Ondatra zibethicus*), and masked shrew (*Sorex cinereus*). Both muskrats and beaver can profoundly influence the hydrology of peatlands. Muskrats create open water channels through the peat, and beavers can cause substantial flooding through their dam-building activities. Beaver dams can cause blocked drainage in fens and the subsequent succession of fens to bogs. Numerous butterflies and moths are restricted to bogs and fens because their food plants occur within these peatlands. In addition, many tiny land snails are associated with calcareous fens.

Rare Plants

Amerorchis rotundifolia (round-leaved orchis, state endangered)
Cacalia plantaginea (prairie Indian-plantain, state special concern)
Carex heleonastes (Hudson Bay sedge, state endangered)
Carex scirpoidea (bulrush sedge, state threatened)
Drosera anglica (English sundew, state special concern)
Empetrum nigrum (black crowberry, state threatened)
Erigeron hyssopifolius (hyssop-leaved fleabane, state threatened)
Juncus stygius (moor rush, state threatened)
Pinguicula vulgaris (butterwort, state special concern)
Rubus acaulis (dwarf raspberry, state endangered)
Solidago houghtonii (Houghton's goldenrod, federal/state threatened)

Rare Animals

Alces americanus (moose, state special concern)
Appalachia arcana (secretive locust, state special concern)
Ardea herodias (great blue heron, protected by the Migratory Bird Treaty Act of 1918)
Asio flammeus (short-eared owl, state endangered)
Botaurus lentiginosus (American bittern, state special concern)
Canis lupus (gray wolf, federal endangered and state threatened)
Catinella exile (Pleistocene catinella, state threatened)
Circus cyaneus (northern harrier, state special concern)
Clemmys guttata (spotted turtle, state threatened)
Coturnicops noveboracensis (yellow rail, state threatened)
Emydoidea blandingii (Blanding's turtle, state special concern)
Euconulus alderi (land snail, state threatened)
Falco columbarius (merlin, state threatened)
Haliaeetus leucocephalus (bald eagle, state special concern)
Hendersonia occulta (cherrystone drop, state threatened)
Lynx canadensis (lynx, state endangered)
Merolonche dolli (Doll's merolonche, state special concern)
Pandion haliaetus (osprey, state special concern)
Phyciodes batesii (tawny crescent, state special concern)
Picoides arcticus (black-backed woodpecker, state special concern)
Planogyra asteriscus (eastern flat-whorl, state special concern)
Pseudacris maculata (boreal chorus frog, state special concern)
Sistrurus c. catenatus (eastern massasauga, federal candidate species and state special concern)
Somatochlora hineana (Hine's emerald, federal/state endangered)
Somatochlora incurvata (incurvate emerald, state special concern).
Terrapene c. carolina (eastern box turtle, state special concern).
Vertigo elatior (tapered vertigo, state special concern)
Vertigo morsei (six-whorl vertigo, endangered)
Vertigo nylanderi (deep-throat vertigo, endangered)
Vertigo pygmaea (crested vertigo, state special concern)

Biodiversity Management Considerations

The primary mechanism for preserving fens is to maintain their hydrology, as slight changes in water chemistry or hydrology result in significant shifts in vegetation. Reduction of access to peatland systems will help decrease detrimental impacts caused by off-road vehicles (ORVs). Increased surface flow and reduction in groundwater recharge can be prevented by establishing no-cut buffers around fens and avoiding road construction and complete canopy removal in

stands immediately adjacent to fens. In addition, road construction through fen should be avoided to prevent hydrologic alterations; roads can impede surface flows and result in complete changes in species composition and structure as a result of sustained flooding on one side of a road while the other side becomes drier and subject to increased shrub and tree encroachment. Where shrub and tree encroachment threatens to convert open wetlands to shrub-dominated systems or forested swamps, prescribed fire or selective cutting can be employed to maintain open conditions. Silvicultural management of fens to preserve open canopy should be employed during the winter to minimize damage to organic soils and impacts to the hydrologic regime.

Monitoring and control efforts to detect and remove invasive species are critical to the long-term viability of northern fen. Particularly aggressive invasive species that have colonized similar habitats such as prairie fen in southern Lower Michigan and thus have the potential to reduce diversity and alter community structure of northern fen in the future include glossy buckthorn (*Rhamnus frangula*), multiflora rose (*Rosa multiflora*), autumn olive (*Elaeagnus umbellata*), purple loosestrife (*Lythrum salicaria*), narrow-leaved cat-tail (*Typha angustifolia*), hybrid cat-tail (*Typha xglauca*), reed canary grass (*Phalaris arundinacea*), and reed (*Phragmites australis*).

Currently, fens are threatened by peat mining, logging, quarrying, agricultural runoff and nutrient enrichment, ORV activity, draining, and flooding. In addition to direct impacts to vegetation, alteration of peatland hydrology from road building, ORVs, quarrying, creation of drainage ditches and dams, and sedimentation and runoff from logging of surrounding uplands has led to significant changes in peatland vegetation composition and structure, as fen vegetation is extremely sensitive to minor hydrologic and chemical changes. Conversion to more eutrophic wetlands has occurred as the result of nutrient enrichment and raised water levels. Eutrophication favors establishment of invasive species. Lower water tables from drainage facilitate tree and shrub encroachment, followed by decreased species richness. In addition, lowering the water table can reduce marl accumulation and thus cause loss of rare calciphilic vegetation.

Variation

Species composition of northern fens varies depending on gradients in nutrient levels and water chemistry. The degree of minerotrophy of a given fen and within a fen depends on a variety of factors including the kind and amount of groundwater discharge; degree of dilution from precipitation; the characteristics of the bedrock and/or glacial deposits the groundwater has percolated through (i.e., older glacial sediments have less dissolved minerals due to prior leaching); the distance the water has traveled through the peatland; the thickness and character of the peat; and the presence or absence of marl.

Northern fens are strongly influenced by regional geomorphology. Fens occurring on former glacial lakebeds and drainageways tend to be more extensive than kettle fens, which are limited in area by the size of the glacial ice-block that formed the basin.

Similar Natural Communities

Coastal fen, Great Lakes marsh, interdunal wetland, intermittent wetland, muskeg, patterned fen, poor fen, prairie fen, rich conifer swamp, and wooded dune and swale complex.

Relevant Literature

Amon, J.P., C.A. Thompson, Q.J. Carpenter, and J. Mines. 2002. Temperate zone fens of the glaciated Midwestern USA. *Wetlands* 22(2): 301-317.

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For a full list of references used to create this description, please refer to the natural community abstract for northern fen.

Coastal Fen

Global/State Rank: G1G2/S2

Overview

Coastal fen is a sedge- and rush-dominated wetland that occurs on calcareous substrates along Lake Huron and Lake Michigan north of the climatic tension zone. The community occurs where marl and organic soils accumulate in protected coves and abandoned coastal embayments and grade to moderately alkaline glacial tills and lacustrine sediments lakeward. Sediments along the lakeshore are typically fine-textured and rich in calcium and magnesium carbonates. Vegetation is comprised primarily of calcicolous species capable of growing on wet alkaline substrates.

Landscape Context

Coastal fen occurs along the flat, saturated shorelines of northern Lake Huron, Lake Michigan, and the Georgian Bay on glacial lakeplains and where thin, discontinuous layers of glacial till overlay limestone. The community frequently develops where groundwater seepage percolates from either calcareous uplands or joints in the underlying limestone bedrock. Coastal fens frequently occur as part of a larger wetland complex that may include Great Lakes marsh, wooded dune and swale complex, rich conifer swamp, and northern fen. The surrounding uplands are typically dominated by mesic northern forest and boreal forest and can contain a significant component of northern white-cedar (*Thuja occidentalis*).

Soils

Soils of coastal fen may range from neutral to moderately alkaline, fine-textured sand to clay in areas immediately adjacent to the lake, to marl and organic sediments in protected coastal embayments less influenced by storm waves. When lake levels rise, areas closer the lakeshore become inundated and storm waves can wash away loose organic and marl sediments.

Natural Processes

Coastal fens are minerotrophic wetlands that receive groundwater inputs rich in calcium and magnesium carbonates. The high mineral content of the groundwater is derived from the limestone and dolomite of the Niagaran escarpment and calcareous glacial tills and lacustrine clays exposed by wave action along the Great Lakes shoreline. The hydrologic regime of coastal fens is directly linked to that of the Great Lakes. As such, the water table is not stable, being subject to seasonal fluctuations in Great Lakes water levels, short-term changes due to seiches and storm surges, and long-term, multi-year lake level fluctuations. Windthrow caused by severe storms along the shoreline of Lakes Michigan and Huron can expand coastal fen farther inland, especially during Great Lakes high-water periods.

Marl forms as a calcium carbonate precipitate through the metabolic activity of algae growing in hard water lakes and calcareous wetlands. In coastal fens, extensive marl flats develop in protected areas farther from the shoreline, where marl accumulates in shallow water and eventually becomes sparsely vegetated by a unique suite of species able to survive in wet alkaline conditions.

Vegetation

Coastal fens share the herbaceous flora of northern fens, but lack the diverse moss flora and tall shrub and tree layers in areas immediately adjacent to the Great Lakes. Most of the graminoids of coastal fens are rhizomatous, an adaptation well suited to the dynamic environment of the Great Lakes shoreline. The most abundant grasses and sedges include twig-rush (*Cladium mariscoides*),

bluejoint grass (*Calamagrostis canadensis*), little bluestem (*Andropogon scoparius*), hair grass (*Deschampsia cespitosa*), hardstem bulrush (*Schoenoplectus acutus*), tufted bulrush (*Trichophorum cespitosum*), Baltic rush (*Juncus balticus*), golden-seeded spike-rush (*Eleocharis elliptica*), beaked spike-rush (*E. rostellata*), white beak-rush (*Rhynchospora alba*), and sedges (*Carex flava*, *C. viridula*, *C. lasiocarpa*, *C. buxbaumii*, *C. capillaris*, and *C. eburnea*).

The common forbs of coastal fen include many species occurring in other calcium-rich habitats along northern Lake Michigan and Lake Huron including false asphodel (*Tofieldia glutinosa*), low calamint (*Calamintha arkansana*), Kalm's lobelia (*Lobelia kalmii*), grass-of-Parnassus (*Parnassia glauca*), Ohio goldenrod (*Solidago ohioensis*), bog goldenrod (*S. uliginosa*), common bog arrow-grass (*Triglochin maritimum*), Indian paintbrush (*Castilleja coccinea*), dwarf Canadian primrose (*Primula mistassinica*), balsam ragwort (*Senecio pauperculus*), small fringed gentian (*Gentianopsis procera*), mermaid-weed (*Proserpinaca palustris*), bastard toadflax (*Comandra umbellata*), small yellow lady's-slipper (*Cypripedium calceolus* var. *parviflorum*), grass-leaved goldenrod (*Euthamia graminifolia*), common water horehound (*Lycopus americanus*), and white camas (*Zigadenus glaucus*). Several carnivorous plants grow in the coastal fens, including sundew (*Drosera rotundifolia*), pitcher-plant (*Sarracenia purpurea*), butterwort (*Pinguicula vulgaris*, state special concern), and bladderworts (*Utricularia cornuta* and *U. intermedia*). These carnivorous species can survive in habitats where nitrogen supplies are limited and are well adapted to the calcareous environment of coastal fens.

Shrubs found in coastal fen include shrubby cinquefoil (*Potentilla fruticosa*), Labrador tea (*Ledum groenlandicum*), sweet gale (*Myrica gale*), large cranberry (*Vaccinium macrocarpon*), creeping juniper (*Juniperus horizontalis*), Kalm's St. John's-wort (*Hypericum kalmianum*), and soapberry (*Shepherdia canadensis*). Shrub-sized northern white-cedar (*Thuja occidentalis*), tamarack (*Larix laricina*), balsam poplar (*Populus balsamifera*), and paper birch (*Betula papyrifera*) are often scattered throughout the fen but are often killed when Great Lakes water levels rise, especially in low areas and those adjacent to the lake.

Vegetation changes quickly when water levels change. Among the species that appear in large numbers when the water level drops are butterwort, Kalm's St., John's-wort, low calamint, Kalm's lobelia, grass-of-Parnassus, Indian paintbrush, dwarf Canadian primrose, and Houghton's goldenrod (*Solidago houghtonii*, federal/state threatened).

Noteworthy Animals

Numerous butterflies and moths are restricted to fens because their food plants occur within these wetland systems, but inventories have not been done within the coastal fen community to determine if these species utilize this open shoreline habitat. In addition, many land snails are associated with coastal fens, including the rare species listed below. Crayfish and minnow populations are abundant within coastal fens during high water years. Hine's emerald dragonfly (*Somatochlora hineana*, federal/state endangered) utilizes coastal fens and their larvae inhabit crayfish burrows.

Rare Plants

Cacalia plantaginea (prairie Indian-plantain, state special concern)

Carex scirpoidea (bulrush sedge, state threatened)

Drosera anglica (English sundew, state special concern)

Pinguicula vulgaris (butterwort, state special concern)

Solidago houghtonii (Houghton's goldenrod, federal/state threatened)

Rare Animals

Ardea herodias (great blue heron, protected by the Migratory Bird Treaty Act of 1918)
Botaurus lentiginosus (American bittern, state special concern)
Catinella exile (Pleistocene catinella, state threatened)
Circus cyaneus (northern harrier, state special concern)
Emydoidea blandingii (Blanding's turtle, state special concern)
Euconulus alderi (land snail, state threatened)
Merolonche dolli (Doll's merolonche, state special concern)
Pandion haliaetus (osprey, state special concern)
Phyciodes batesii (tawny crescent, state special concern)
Planogyra asteriscus (eastern flat-whorl, state special concern)
Sistrurus c. catenatus (eastern massasauga, federal candidate species and state special concern)
Somatochlora hineana (Hine's emerald, federal/state endangered)
Somatochlora incurvata (incurvate emerald, state special concern)
Terrapene c. carolina (eastern box turtle, state special concern)
Vertigo elatior (tapered vertigo, state special concern)
Vertigo morsei (six-whorl vertigo, endangered)
Vertigo pygmaea (crested vertigo, state special concern)
Williamsonia fletcheri (ebony boghaunter, state special concern)

Biodiversity Management Considerations

Protecting the hydrology of coastal fens is critical to their long-term viability. Increased surface flow and reduction in groundwater recharge can be prevented by establishing no-cut buffers around coastal fens and avoiding road construction and complete canopy removal in stands immediately adjacent to fens. In addition, road construction through fens should be avoided to prevent hydrologic alterations; roads can impede surface flows and result in significant changes in species composition and structure as a result of sustained flooding on one side of a road while the other side becomes drier and subject to increased shrub and tree encroachment. Off-road vehicles can create deep ruts in the loose soils of coastal fen, altering surface flows and species composition, and creating opportunities for invasive plants to establish.

Particularly aggressive invasive species that have the potential to threaten diversity and structure of coastal fens include glossy buckthorn (*Rhamnus frangula*), purple loosestrife (*Lythrum salicaria*), narrow-leaved cat-tail (*Typha angustifolia*), hybrid cat-tail (*Typha xglauca*), reed canary grass (*Phalaris arundinacea*), and reed (*Phragmites australis*). Monitoring and control efforts to detect and remove invasive plants before they become widespread will help maintain the ecological integrity of coastal fens and surrounding natural communities.

Variation

Species composition of coastal fen varies depending on gradients in nutrient levels and water chemistry. For most coastal fens in Michigan, there is limited observable groundwater flow, but for others such as Thompson's Harbor in Presque Isle County and Peck Bay in Mackinac County, groundwater seepages are clearly visible. Coastal fens are located where Devonian, Silurian, and Ordovician limestone and dolomite are at or near the surface, providing a source of carbonate-rich groundwater. Differences in bedrock characteristics determine the prevalence of seepages and springs. Calcium-rich lacustrine clays and tills also provide suitable substrates for development of coastal fens.

Similar Natural Communities

Limestone cobble shore, Great Lakes marsh, prairie fen, interdunal wetland, northern fen, rich conifer swamp, and wooded dune and swale complex.

Relevant Literature

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For a full list of references used to create this description, please refer to the natural community abstract for coastal fen.

Patterned Fen

Global/State Rank: GU/S2

Overview

Patterned fen is a minerotrophic shrub- and herb-dominated peatland mosaic characterized by a series of peat ridges (strings) and hollows (flarks) oriented parallel to the slope of the landform and perpendicular to the flow of groundwater. The strings vary in height, width, and spacing, but are generally less than one meter tall, resulting in a faint wave-like pattern that may be discernable only from aerial photographs. The flarks are saturated to inundated open lawns of sphagnum mosses, sedges, and rushes, while the strings are dominated by sedges, shrubs, and scattered, stunted trees. Patterned fens occur in the eastern Upper Peninsula, with the highest concentration found in Schoolcraft County. Patterned fens are also referred to as patterned bogs, patterned peatlands, strangmoor, aapamires, and string bogs.

Landscape Context

Patterned fens are prominent features in the boreal and sub-boreal regions of North America, Europe, and Siberia. This natural community reaches its southern extent in the Great Lakes States of Minnesota, Wisconsin, and Michigan. Fourteen high-quality patterned fens, totaling approximately 34,000 acres, have been documented in the eastern Upper Peninsula in Alger, Chippewa, Delta, Luce, Mackinac, and Schoolcraft Counties.

Landscapes that support patterned fens exhibit a gradual slope of approximately 2%, or two to twelve feet per mile. Patterned fens are located on expansive, poorly drained sandy glacial lakeplains and broad outwash channels immediately adjacent to glacial lakeplains. Patterned fens occur as part of larger wetland complexes and border other peatland types, especially muskeg. Additional wetland communities associated with patterned fen include poor fen, northern wet meadow, northern shrub thicket, intermittent wetland, and rich conifer swamp. Narrow transverse dune ridges within patterned fen complexes are common and support dry northern forest and dry-mesic northern forest.

Soils

Peat (including fibric, hemic, and sapric peat) forms the substrate for both the strings and flarks of patterned fen communities. Peat can be several meters deep (10 to 25 feet for Lake Agassiz peatlands of Minnesota) and is derived from sedges, sphagnum mosses, reeds, and moderately decomposed woody material. The saturated peat ranges from medium acid to circumneutral. The flarks tend to be wetter, slightly acidic to circumneutral, and more minerotrophic than the strings, although nutrient availability and pH can differ greatly both within and among patterned peatland systems. The amount of water in the flarks also varies depending on local hydrology, precipitation, and season.

Natural Processes

Given the level to gently sloping topography of patterned fens, peat formation and expansion are primarily the result of paludification, the encroachment of sphagnum mosses into adjacent terrestrial systems. The sphagnum mosses responsible for paludification may have originated from nearby peat-filled lake basins or other peat-accumulating depressional wetlands.

Several hypotheses have been proposed to explain the subtle dynamics responsible for the patterning within patterned fens. Most researchers agree that the direction of water movement is

an essential factor as the strings and flarks are consistently oriented perpendicular to the direction of water flow. Early research suggested that strings and flarks are a result of permafrost and frost action, but patterned peatlands have since been documented in northern Michigan, Minnesota, and southern Wisconsin, where permafrost is absent. Another hypothesis to explain the origin of strings and flarks is the gradual down-slope slipping of peat. In this hypothesis, peat moves downslope until the advancing soil catches on a subsurface irregularity, such as a rock or tree, and stabilizes to form a string, eventually creating a patterning effect across the peatland. Others suggest that the string and flark patterning is the result of gradual expansion and merger of hollows created in sedge hummock-hollow microtopography within the peatland. This process is thought to be controlled by differential rates of peat accumulation and enhanced by active peat degradation within the hollows. Further research is needed to completely understand the complex biotic, chemical, and physical interactions occurring within patterned fens. Additional research on the fire regimes of patterned fens is warranted. During drought years, fire is an important disturbance factor influencing the species composition and structure of patterned fen and also potentially impacting the patterning.

Vegetation

Vegetation of the alternating strings and flarks can differ in species composition and structure. The strings are comprised of slightly raised ridges of peat and are dominated by sedges, forbs, and small shrubs including the following species: sedges (*Carex oligosperma*, *C. sterilis*, and *C. lasiocarpa*), round-leaved sundew (*Drosera rotundifolia*), royal fern (*Osmunda regalis*), bog aster (*Aster nemoralis*), bog goldenrod (*Solidago uliginosa*), pitcher-plant (*Sarracenia purpurea*), bog birch (*Betula pumila*), shrubby cinquefoil (*Potentilla fruticosa*), bog rosemary (*Andromeda glaucophylla*), leatherleaf (*Chamaedaphne calyculata*), black chokeberry (*Aronia prunifolia*), bog willow (*Salix pedicellaris*), and bog laurel (*Kalmia polifolia*). Scattered and stunted trees of black spruce (*Picea mariana*), northern white-cedar (*Thuja occidentalis*), and tamarack (*Larix laricina*) are also found on the strings but generally cover less than 10% of the area. The flarks consist of level areas or hollows between slightly elevated strings and are dominated by sphagnum mosses, sedges, and rushes including the following species: sphagnum mosses (i.e., *Sphagnum angustifolium*, *S. fuscum*, and *S. magellanicum*), sedges (*Carex limosa*, *C. livida*, *C. lasiocarpa*, and *C. exilis*), spoon-leaf sundew (*Drosera intermedia*), white beak-rush (*Rhynchospora alba*), large cranberry (*Vaccinium macrocarpon*), twig-rush (*Cladium mariscoides*), Canadian rush (*Juncus canadensis*), water horsetail (*Equisetum fluviatile*), bog buckbean (*Menyanthes trifoliata*), arrow-grass (*Scheuchzeria palustris*), three-way sedge (*Dulichium arundinaceum*), and flat-leaved bladderwort (*Utricularia intermedia*). Additional characteristic species of patterned fen include dragon's mouth (*Arethusa bulbosa*), sedges (*Carex buxbaumii*, *C. echinata*), tufted bulrush (*Trichophorum cespitosum*), English sundew (*Drosera anglica*), marsh cinquefoil (*Potentilla palustris*), marsh St. John's-wort (*Triadenum fraseri*), golden-seeded spike-rush (*Eleocharis elliptica*), narrow-leaved cotton-grass (*Eriophorum angustifolium*), and common bog arrow-grass (*Triglochin maritimum*). Linear bands or teardrops of rich conifer swamp and northern shrub thicket commonly occur within patterned fens. In addition, low, narrow dune ridges dominated by pines also characterize patterned peatland landscapes.

Noteworthy Animals

Beaver (*Castor canadensis*) can build dams on streams that drain patterned fen, raising water levels and killing trees and other plants not able to tolerate rising water levels or adapted to prolonged flooding. Tree survival is also limited by insects and parasites. Insect outbreaks of larch sawfly (*Pristiphora erichsonii*) cause heavy mortality of tamarack, while the plant parasite dwarf mistletoe (*Arceuthobium pusillum*) kills black spruce.

Rare Plants

Amerorchis rotundifolia (round-leaved orchis, state endangered)
Bartonia paniculata (panicled screw-stem, state threatened)
Carex heleonastes (Hudson Bay sedge, state endangered)
Carex novae-angliae (New England sedge, state threatened)
Drosera anglica (English sundew, state special concern)
Juncus stygius (Moor rush, state threatened)
Petasites sagittatus (sweet coltsfoot, state threatened)
Rubus acaulis (dwarf raspberry, state endangered)

Rare Animals

Alces americanus (moose, state special concern)
Boloria freija (Freija fritillary, state special concern)
Boloria frigga (Frigga fritillary, state special concern)
Canis lupus (gray wolf, federal endangered and state threatened)
Circus cyaneus (northern harrier, state special concern)
Emydoidea blandingii (Blanding's turtle, state special concern)
Erebia discoidalis (red-disked alpine, state special concern)
Falci pennis canadensis (spruce grouse, state special concern)
Falco columbarius (merlin, state threatened)
Somatochlora hineana (Hine's emerald, federal/state endangered)
Somatochlora incurvata (incurvate emerald, state special concern)
Williamsonia fletcheri (ebony boghaunter, state special concern)

Biodiversity Management Considerations

A major threat to patterned fen is hydrologic alteration through ditching, damming, logging, and trail- and road-building activities, which can result in significant changes to peatland composition and structure. Peat mining also threatens pristine peatland systems. Effective conservation of patterned peatlands should include protecting and/or restoring the natural hydrology of the peatland and surrounding watershed.

Monitoring and control efforts to detect and remove invasive species before they become widespread are critical to the long-term viability of patterned fen. Invasive species that may threaten diversity and community structure of patterned fen include glossy buckthorn (*Rhamnus frangula*), multiflora rose (*Rosa multiflora*), purple loosestrife (*Lythrum salicaria*), narrow-leaved cat-tail (*Typha angustifolia*), hybrid cat-tail (*Typha xglauca*), reed canary grass (*Phalaris arundinacea*), and reed (*Phragmites australis*).

Variation

Vegetation and patterning can vary significantly within and among patterned fens and is influenced by groundwater flow and past disturbances events such as fire and flooding.

Similar Natural Communities

Northern fen, coastal fen, poor fen, northern wet meadow, northern shrub thicket, muskeg, rich conifer swamp, and poor conifer swamp.

Relevant Literature

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For a full list of references used to create this description, please refer to the natural community abstract for patterned fen.

Poor Fen

Global/State Rank: G3G5/S3

Overview

Poor fen is a sedge-dominated wetland found on very strongly to strongly acid, saturated peat that is moderately influenced by groundwater. The community occurs north of the climatic tension zone in kettle depressions and in flat areas or mild depressions on glacial outwash and glacial lakeplain.

Landscape Context

Poor fen occurs in flat areas and shallow depressions on sandy glacial outwash and glacial lakeplain, and in kettle depressions on pitted outwash and moraines. Poor fens found in kettle depressions are associated with active or extinct glacial lakes. Within kettle depressions, poor fens can occupy the entire basin or occur as a floating mat along the margin of a remaining glacial lake. Poor fens occurring on former glacial lakebeds and drainageways tend to be more extensive than kettle fens, which are limited in area by the size of the glacial ice-block that formed the basin. The overall topography of poor fens is flat with microtopography often characterized by hummocks and hollows. Poor fens occur adjacent to other peatland communities, often grading into bog, poor conifer swamp, and muskeg. More minerotrophic systems such as northern fen, northern shrub thicket, northern wet meadow, and rich conifer swamp can occur along the outer margins of poor fens where groundwater seepage from adjacent uplands is prevalent. Upland community types neighboring poor fen typically include fire-adapted communities such as pine barrens, dry northern forest, and dry-mesic northern forest.

Soils

The organic soils of poor fens are composed of peat, which frequently forms a shallow, continuous mat ranging from one to three meters in depth. Organic soils near the surface are fibric peat and very strongly to strongly acid with low nutrient availability. Low levels of groundwater input combined with high water-retaining capacity of fibric peat produce continuously saturated conditions in the rooting zone of poor fens. The water table of poor fens is stable, typically at the soil surface with soils remaining saturated but seldom flooded. The surface waters of poor fens are characterized by very strong to strong acidity, low available nutrients, low specific conductivity, cool temperatures, moderate levels of dissolved organic matter, and anaerobic conditions.

Natural Processes

Poor fens are weakly minerotrophic peatlands, receiving inputs of water and nutrients from both ion-poor precipitation and low exposure to nutrient-rich groundwater. The acidity of poor fens limits the availability and uptake of essential mineral nutrients by plants. Saturated and inundated conditions inhibit organic matter decomposition and allow for the accumulation of peat. Under cool, anaerobic, and acidic conditions, the rate of organic matter accumulation exceeds organic decay. Development and expansion of fens occurs via two different processes in glacial lakeplains and outwash plains versus kettle depressions. Fens develop in glacial lakeplains and outwash where groundwater influence maintains saturated conditions. Peat develops vertically and spreads horizontally. Lake-filling occurs in small kettle lakes with minimal wave action where gradual peat accumulation results in the development of a sedge mat that can fill the basin or form a floating mat in the lake or a grounded mat along the water's edge. Floating mats of fen sedges, such as wiregrass sedge (*Carex lasiocarpa*), are able to pioneer open water and

submergent and emergent marshes. The interlacing of rhizomes and roots forms a floating mat that is buoyed by the water and accumulates organic matter in the form of sapric peat. Over time, fen mats are often invaded by ericaceous shrubs and acidifying sphagnum mosses. The invasion of sphagnum moss into rich fen systems such as northern fen often results in conversion to more acidic communities such as poor fen or bog.

Natural disturbance factors influencing poor fens include fire, flooding, windthrow, and insects. Surface fire can contribute to the maintenance of fens by killing encroaching trees and tall shrubs, and promoting graminoid dominance. In addition, many of the ericaceous shrub species resprout following fire. In the absence of fire, a thick layer of leaf litter can develop that stifles seedling establishment and seed bank expression. Fire severity and frequency in fens is closely related to landscape context and fluctuations in water level. Prolonged periods of lowered water table can allow the surface peat to dry out sufficiently to burn. Such peat fires can result in the conversion of peatland to mineral soil wetland. Peat fires within bogs can also release enough nutrients to favor succession to more minerotrophic peatlands such as poor fen or intermittent wetland. Lowering of the water table of fens can also result in the increase in decomposition rates of organic matter and the subsequent accumulation of compact peat that is more conducive to shrub and tree growth. In such a circumstance, poor fen can succeed to poor conifer swamp or northern shrub thicket. Flooding, often caused by beaver activity, can contribute to the maintenance of fens and also result in the conversion of fens to bogs. Roots of peatland trees are physiologically active near the surface and are killed when the water table rises during prolonged flooding. Trees growing in fens are particularly susceptible to windthrow because peat provides a poor substrate for anchoring trees and the anaerobic conditions associated with saturated soils prevent trees from rooting deeply. Tree survival in fens is also limited by insects and parasites. Insect outbreaks of larch sawfly (*Pristiphora erichsonii*) cause heavy mortality of tamarack (*Larix laricina*), while the plant parasite dwarf mistletoe (*Arceuthobium pusillum*) kills black spruce (*Picea mariana*).

Vegetation

Poor fens have a unique flora that is intermediate between northern fen and bog. Poor fens are characterized by a graminoid-dominated herbaceous layer of low to moderate diversity. While sedges remain dominant, many poor fens also support a continuous carpet of sphagnum mosses and widely scattered, slightly raised peat ridges or mounds with low ericaceous, evergreen shrubs and stunted conifer trees. Gradients in pH, light, soil moisture, and cation concentrations (i.e., nutrient availability) determine floristic composition of poor fens. Sedges dominate the species-poor herbaceous layer of poor fens. Few-seed sedge (*Carex oligosperma*) and wiregrass sedge (*Carex lasiocarpa*) are typically dominant. Other sedges that are characteristic of poor fens include creeping sedge (*Carex chordorrhiza*), coastal sedge (*C. exilis*), livid sedge (*C. livida*), few-flower sedge (*C. pauciflora*), and mud sedge (*C. limosa*). Additional graminoids that thrive in poor fens include twig-rush (*Cladium mariscoides*), three-way sedge (*Dulichium arundinaceum*), cotton-grasses (*Eriophorum* spp.), swamp candles (*Lysimachia terrestris*), white beak-rush (*Rhynchospora alba*), arrow-grass (*Scheuchzeria palustris*), and tufted bulrush (*Trichophorum cespitosum*). The following is a list of prevalent herbaceous plants occurring in poor fen: rush aster (*Aster borealis*), fireweed (*Epilobium angustifolium*), fringed willow-herb (*E. ciliatum*), grass-leaved goldenrod (*Euthamia graminifolia*), wild blue flag (*Iris versicolor*), bog buckbean (*Menyanthes trifoliata*), marsh cinquefoil (*Potentilla palustris*), false mayflower (*Smilacina trifolia*), bog goldenrod (*Solidago uliginosa*), and common bog arrow-grass (*Triglochin maritimum*). Insectivorous plants, round-leaved sundew (*Drosera rotundifolia*), spoon-leaf sundew (*D. intermedia*), pitcher-plant (*Sarracenia purpurea*), horned bladderwort (*Utricularia cornuta*), and flat-leaved bladderwort (*U. intermedia*), are common features of poor fens. Where a continuous moss layer occurs, it is dominated by sphagnum mosses, especially

Sphagnum magellanicum, *S. angustifolium*, *S. capillaceum*, *S. capillifolium*, *S. recurvum*, *S. papillosum*, and *S. fuscum*.

The patchy shrub layer of poor fens is dominated by low, ericaceous shrubs including bog rosemary (*Andromeda glaucophylla*), leatherleaf (*Chamaedaphne calyculata*), bog laurel (*Kalmia polifolia*), Labrador tea (*Ledum groenlandicum*), large cranberry (*Vaccinium macrocarpon*), and small cranberry (*V. oxycoccos*). Other important associates of the low shrub layer include sweet gale (*Myrica gale*), bog willow (*Salix pedicellaris*), and meadowsweet (*Spiraea alba*). The tall shrub layer of poor fens is less dense than the low shrub layer and is often restricted to the periphery. Tall shrubs typical of poor fens include black chokeberry (*Aronia prunifolia*), mountain holly (*Nemopanthus mucronata*), pussy willow (*Salix discolor*), steeplebush (*Spiraea tomentosa*), wild-raisin (*Viburnum cassinoides*), and meadowsweet. More minerotrophic shrubs, like bog birch (*Betula pumila*), Kalm's St. John's-wort (*Hypericum kalmianum*), and shrubby cinquefoil (*Potentilla fruticosa*), can occur in poor fens where their roots extend beneath the surface mat to minerotrophic peat. Trees within poor fens are widely scattered (tree cover is typically less than 10%), stunted (seldom reaching six meters), and are often restricted to scattered, low peat mounds. The most commonly occurring trees in poor fens are black spruce (*Picea mariana*) and tamarack (*Larix laricina*), with jack pine (*Pinus banksiana*) and white pine (*P. strobus*) as occasional associates.

Noteworthy Animals

Poor fens provide important habitat for small mammals such as short-tailed shrew (*Blarina brevicauda*), beaver (*Castor canadensis*), meadow vole (*Microtus pennsylvanicus*), mink (*Mustela vison*), muskrat (*Ondatra zibethicus*), and masked shrew (*Sorex cinereus*). Both muskrats and beaver can profoundly influence the hydrology of peatlands. Muskrats create open water channels through the peat and beavers can cause substantial flooding through their dam-building activities. Beaver dams can cause blocked drainage in fens and the subsequent succession of fens to bogs. Numerous butterflies and moths are restricted to bogs and fens because their food plants occur within these open peatland systems.

Rare Plants

Carex nigra (black sedge, state endangered)
Carex wiegandii (Wiegand's sedge, state special concern)
Eleocharis nitida (slender spike-rush, state endangered)
Petasites sagittatus (sweet coltsfoot, state threatened)

Rare Animals

Alces americanus (moose, state special concern)
Appalachia arcana (secretive locust, state special concern)
Ardea herodias (great blue heron, protected by the Migratory Bird Treaty Act of 1918)
Asio flammeus (short-eared owl, state endangered)
Boloria freija (Freija fritillary, state special concern)
Boloria frigga (Frigga fritillary, state special concern)
Botaurus lentiginosus (American bittern, state special concern)
Canis lupus (gray wolf, federal endangered and state threatened)
Circus cyaneus (northern harrier, state special concern)
Clemmys guttata (spotted turtle, state threatened)
Coturnicops noveboracensis (yellow rail, state threatened)
Emydoidea blandingii (Blanding's turtle, state special concern)
Erebria discoidalis (red-disked alpine, state special concern)
Falci pennis canadensis (spruce grouse, state special concern)

Falco columbarius (merlin, state threatened)
Haliaeetus leucocephalus (bald eagle, state special concern)
Lynx canadensis (lynx, state endangered)
Merolonche dolli (Doll's merolonche, state special concern)
Pandion haliaetus (osprey, state special concern)
Phyciodes batesii (tawny crescent, state special concern)
Picoides arcticus (black-backed woodpecker, state special concern)
Pseudacris maculata (boreal chorus frog, state special concern)
Sistrurus c. catenatus (eastern massasauga, federal candidate species and state special concern)
Somatochlora incurvata (incurvate emerald, state special concern)
Terrapene c. carolina (eastern box turtle, state special concern)
Williamsonia fletcheri (ebony boghaunter, state special concern)

Biodiversity Management Considerations

The primary mechanism for preserving poor fens is to maintain their hydrology and water chemistry. A serious threat to poor fens is posed by off-road vehicle (ORV) traffic, which can destroy populations of sensitive species and significantly alter fen hydrology through rutting. Reducing access to peatland systems will help decrease detrimental impacts. Increased surface water inputs and reductions in groundwater recharge can be prevented by avoiding road construction and complete canopy removal in stands immediately adjacent to fens. Where shrub and tree encroachment threatens to convert open wetlands to shrub-dominated systems or forested swamps, prescribed fire or selective cutting can be employed to maintain open conditions. Silvicultural management of poor fens to preserve open canopy should be employed during the winter to minimize damage to the peat and impacts to the hydrologic regime. Where feasible, fires originating in adjacent uplands should be allowed to burn across poor fens when they do not pose serious safety concerns or threaten other management objectives.

Poor fens are primarily threatened by changes to their hydrology and water chemistry, which may result from road building, ORVs, quarrying, peat mining, creation of drainage ditches and dams, agricultural runoff and nutrient enrichment, or runoff from logging. Fen vegetation is extremely sensitive to minor changes in water levels, water chemistry, groundwater flow, and nutrient availability. A reduction in groundwater flow and subsequent decrease in nutrients in poor fens can result in the shift to less minerotrophic wetlands such as bog. Lowered water tables from drainage allow tree and shrub encroachment into open fens and the eventual succession to closed-canopy peatlands. Conversion to more eutrophic wetlands has occurred as the result of nutrient enrichment and raised water levels, which cause increased decomposition of peat soils. Eutrophication from pollution and altered hydrology has detrimentally impacted fens by generating conditions favorable for invasive species. Monitoring and control efforts to detect and remove invasive species are critical to the long-term viability of poor fen. Particularly aggressive invasive species that may threaten the diversity and community structure of poor fen include purple loosestrife (*Lythrum salicaria*), narrow-leaved cat-tail (*Typha angustifolia*), hybrid cat-tail (*Typha xglauca*), reed (*Phragmites australis*), reed canary grass (*Phalaris arundinacea*), European marsh thistle (*Cirsium palustre*), glossy buckthorn (*Rhamnus frangula*), and multiflora rose (*Rosa multiflora*).

Variation

Species composition of poor fens varies depending on gradients in nutrient levels and water chemistry. The degree of minerotrophy of a given fen and within a fen depends on a variety of factors including the amount of groundwater discharge and its chemistry; degree of dilution from precipitation; the characteristics of the bedrock and/or glacial deposits the groundwater has percolated through (i.e., older glacial sediments have less dissolved minerals due to prior

leaching); the distance the water has traveled through the peatland; and the thickness and character of the peat. Fens occurring on former glacial lakebeds and drainageways tend to be more extensive than kettle fens, which are limited in area by the size of the glacial ice-block that formed the basin.

Similar Natural Communities

Bog, coastal fen, intermittent wetland, muskeg, northern fen, northern wet meadow, patterned fen, poor conifer swamp, prairie fen, and rich conifer swamp.

Relevant Literature

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For a full list of references used to create this description, please refer to the natural community abstract for poor fen.

BOG COMMUNITIES

Bog

Global/State Rank: G3G5/S4

Overview

Bog is a nutrient-poor peatland characterized by acidic, saturated peat and the prevalence of sphagnum mosses and ericaceous shrubs. Fire and flooding are the main natural disturbance factors.

Landscape Context

Bogs occur in kettle depressions on pitted outwash and moraines and in flat areas and shallow depressions on glacial outwash and glacial lakeplain. Within kettle depressions, bogs can occupy the entire basin or occur as a mat (floating or grounded) on the margins of lakes. Bogs occurring on former glacial lakebeds and drainageways tend to be more extensive than kettle bogs, which are limited in area by the size of the glacial ice-block that formed the basin. The overall topography of bogs is flat to gently undulating with microtopography characterized by hummocks and hollows.

Soils

The organic soils are composed of saturated fibric peat that contains partially decomposed sphagnum mosses and frequently, fragments of sedges and wood. Like the surface water, peat soils are extremely acidic, cool, and characterized by low nutrient availability and oxygen levels. The water-retaining capacity of sphagnum peat is tremendous and as a result bogs are saturated, anoxic systems with water tables near the surface. Peat composition changes with depth and is influenced by the successional history of a given site. Fiber content and hydraulic conductivity of peat soils usually decrease with depth.

Natural Processes

Saturated and inundated conditions inhibit organic matter decomposition and allow for the accumulation of peat. Under cool, anaerobic, and acidic conditions, the rate of organic matter accumulation exceeds organic decay. Once sphagnum mosses become established on the peat mat, they maintain and enhance saturated and acidic conditions, which in turn promote continued peat development. Development and expansion of peatlands occur via two distinct processes: lake-filling and paludification. Lake-filling occurs in small lakes with minimal wave action, where gradual peat accumulation results in the development of a bog mat that can fill the basin or occur as a floating mat or grounded mat. Paludification is the blanketing of terrestrial systems (often forests) by the overgrowth of peatland vegetation. Paludified peatlands develop on flat areas (typically lakeplains) where peat develops vertically and spreads horizontally. For both lake-filling and paludification, peat accumulates above the water table and the bog becomes isolated from the influence of groundwater. Bogs are ombrotrophic to weakly minerotrophic peatlands, receiving inputs of water and nutrients primarily from ion-poor precipitation.

Natural disturbance factors influencing bogs include fire, flooding, windthrow, and insects. Surface fire can contribute to the maintenance of bogs by killing encroaching trees. Fire severity and frequency in bogs is closely related to fluctuations in water level and landscape context; sites

adjacent to fire-prone uplands burn more frequently. Prolonged periods of lowered water table can allow the surface peat to dry out sufficiently to burn. Flooding contributes to the development, expansion, and maintenance of bogs. Dam-building activities of beaver can result in blocked drainage and flooding, which facilitate sphagnum peat development and expansion and can also cause grounded bog mats to become loosened from the bottom and float. Roots of peatland trees are physiologically active near the surface and are quickly killed when the water table rises following prolonged flooding. Trees growing in bogs are particularly susceptible to windthrow because sphagnum peat provides a poor substrate for anchoring trees and the anaerobic conditions associated with saturated soils limit rooting depth. Tree survival in bogs is also limited by insects and parasites. Insect outbreaks of the larch sawfly (*Pristiphora erichsonii*) cause heavy mortality of tamarack (*Larix laricina*). The plant parasite dwarf mistletoe (*Arceuthobium pusillum*) kills black spruce (*Picea mariana*). Native ericaceous shrubs can limit the establishment and growth of conifer trees within bogs through both competitive inhibition and the production of allelopathic compounds.

Vegetation

Bogs are characterized by a continuous carpet of sphagnum moss, a species-poor herbaceous layer, low ericaceous, evergreen shrubs, and widely scattered and stunted conifer trees. The ubiquitous moss layer of bogs is dominated by sphagnum mosses, especially *Sphagnum magellanicum*, *S. angustifolium*, and *S. fuscum*. The shrub layer is dominated by low, ericaceous shrubs with leatherleaf (*Chamaedaphne calyculata*) as the most prevalent species. The following heath shrubs are important components of bogs: bog rosemary (*Andromeda glaucophylla*), huckleberry (*Gaylussacia baccata*), sheep-laurel (*Kalmia angustifolia*), bog laurel (*K. polifolia*), Labrador tea (*Ledum groenlandicum*), low sweet blueberry (*Vaccinium angustifolium*), Canada blueberry (*V. myrtilloides*), large cranberry (*V. macrocarpon*), and small cranberry (*V. oxycoccos*). The tall shrub layer of bogs is less dense than the low shrub layer and is often restricted to the periphery of the bog. Tall shrubs typical of bogs include black chokeberry (*Aronia prunifolia*), mountain holly (*Nemopanthus mucronata*), bog willow (*Salix pedicellaris*), steeplebush (*Spiraea tomentosa*), smooth highbush blueberry (*Vaccinium corymbosum*), and wild-raisin (*Viburnum cassinoides*). South of the climatic tension zone, buttonbush (*Cephalanthus occidentalis*), poison sumac (*Toxicodendron vernix*), and highbush blueberry frequently occur within bogs or along their margins. The herbaceous layer of bogs is dominated by cyperaceous plants. Sedges that are characteristic of bogs include few-seed sedge (*Carex oligosperma*), few-flower sedge (*C. pauciflora*), and wiregrass sedge (*C. lasiocarpa*). Additional graminoids include twig-rush (*Cladium mariscoides*), three-way sedge (*Dulichium arundinaceum*), cotton-grasses (*Eriophorum* spp.), white beak-rush (*Rhynchospora alba*), and bulrushes (*Scirpus* spp.). Insectivorous plants are common features of bogs and may include round-leaved sundew (*Drosera rotundifolia*), spoon-leaf sundew (*D. intermedia*), pitcher-plant (*Sarracenia purpurea*), and flat-leaved bladderwort (*Utricularia intermedia*). Trees within bogs are widely scattered and stunted (seldom reaching six meters in height). The most commonly occurring trees are black spruce (*Picea mariana*) and tamarack (*Larix laricina*), with jack pine (*Pinus banksiana*), white pine (*Pinus strobus*), and red maple (*Acer rubrum*) as occasional associates and the latter being more prevalent south of the climatic tension zone.

Noteworthy Animals

In general, the population of animals is low in bogs because of the low productivity and unpalatability of bog vegetation, and the high acidity of bog water. Swamp sparrow (*Melospiza georgiana*) and song sparrow (*M. melodia*) are typical bog songbirds. Common herptiles that frequent bogs include eastern American toad (*Bufo a. americanus*), northern leopard frog (*Rana pipiens*), and eastern garter snake (*Thamnophis s. sirtalis*). Bogs provide important habitat for small mammals such as short-tailed shrew (*Blarina brevicauda*), beaver (*Castor canadensis*),

meadow vole (*Microtus pennsylvanicus*), mink (*Mustela vison*), muskrat (*Ondatra zibethicus*), and masked shrew (*Sorex cinereus*). Both muskrats and beaver can profoundly influence the hydrology of bogs. Muskrats create open water channels through the bog peat and beavers can cause substantial flooding through their dam-building activities. Numerous butterflies and moths are restricted to bogs and fens because their food plants occur within these peatland systems.

Rare Plants

Betula populifolia (gray birch, state special concern)
Carex wiegandii (Wiegand's sedge, state special concern)
Eleocharis radicans (spike-rush, presumed extirpated from Michigan)
Empetrum nigrum (black crowberry, state threatened)
Isotria verticillata (whorled pogonia, state threatened)
Platanthera ciliaris (orange or yellow fringed orchid, state endangered)
Platanthera leucophaea (eastern prairie fringed orchid, state endangered)
Rubus acaulis (dwarf raspberry, state endangered)
Sarracenia purpurea f. heterophylla (yellow pitcher-plant, state threatened)

Rare Animals

Acris blanchardi (Blanchard's cricket frog, state threatened)
Alces americanus (moose, state special concern)
Appalachia arcana (secretive locust, state special concern)
Ardea herodias (great blue heron, protected by the Migratory Bird Treaty Act of 1918)
Atlanticus davisii (Davis's shield-bearer, state special concern)
Boloria freija (Freija fritillary, state special concern)
Boloria frigga (Frigga fritillary, state special concern)
Botaurus lentiginosus (American bittern, state special concern)
Calephelis mutica (swamp metalmark, state special concern)
Canis lupus (gray wolf, federal endangered and state threatened)
Circus cyaneus (northern harrier, state special concern)
Clemmys guttata (spotted turtle, state threatened)
Coturnicops noveboracensis (yellow rail, state threatened)
Cryptotis parva (least shrew, state threatened)
Emydoidea blandingii (Blanding's turtle, state special concern)
Erebia discoidalis (red-disked alpine, state special concern)
Erynnis baptisiae (wild indigo duskywing, state special concern)
Falcipennis canadensis (spruce grouse, state special concern)
Falco columbarius (merlin, state threatened)
Gavia immer (common loon, state threatened)
Haliaeetus leucocephalus (bald eagle, state special concern)
Liodessus cantralli (Cantrall's bog beetle, state special concern)
Lynx canadensis (lynx, state endangered)
Merolonche dolli (Doll's merolonche, state special concern)
Neoconocephalus lyristis (bog conehead, state special concern)
Nerodia erythrogaster neglecta (copperbelly watersnake, federal threatened and state endangered)
Oecanthus laricis (tamarack tree cricket, state special concern)
Orchelimum concinnum (red-faced meadow katydid, state special concern)
Pandion haliaetus (osprey, state special concern)
Pantherophis spiloides (gray ratsnake, state special concern)
Paroxya hoosieri (Hoosier locust, state special concern)
Picoides arcticus (black-backed woodpecker, state special concern)

Pseudacris maculata (boreal chorus frog, state special concern)
Sistrurus c. catenatus (eastern massasauga, federal candidate species and state special concern)
Somatochlora incurvata (incurvate emerald, state special concern)
Sorex fumeus (smoky shrew, state threatened)
Terrapene c. carolina (eastern box turtle, state special concern)
Williamsonia fletcheri (ebony boghaunter, state special concern)

Biodiversity Management Considerations

The primary mechanism for preserving bogs is to maintain their hydrology. Reducing access to peatland systems will help decrease detrimental impacts caused by off-road vehicles. Minimizing impacts to hydrologic regimes can be accomplished by avoiding surface water inputs from drainage ditches, agricultural fields, road construction, and logging in the adjacent uplands, and maintaining native vegetation types in the uplands around the community. In forested landscapes, establishing no-cut buffers around bogs and avoiding road construction and complete canopy removal in stands immediately adjacent to wetlands can help protect the hydrologic regime. In fire-prone landscapes, where shrub and tree encroachment threatens to convert open wetlands to shrub-dominated systems or forested swamps, prescribed fire or selective cutting can be employed to maintain open conditions. Ideally, prescribed fires conducted in adjacent fire-dependent upland communities would be allowed to carry into open wetlands such as bogs when safety permits. Silvicultural management of bogs to preserve open canopy should be employed during winter to minimize damage to peat and impacts to the hydrologic regime.

Historically, widespread fires following turn-of-the-century logging significantly altered many peatlands, either converting poor conifer swamp to open bog systems or destroying the peat and converting bogs to wetlands without organic soils (mineral soil wetlands). Logging of cedar and tamarack from peatland systems also favored the conversion of forested peatlands to open, ombrotrophic bogs. In landscapes where frequent fire was the prevalent disturbance factor, fire suppression has led to the conversion of open bogs to closed-canopy peatlands. Peat mining and cranberry farming have degraded numerous bogs throughout the region. In addition to direct impacts to vegetation, alteration of peatland hydrology from road building, creation of drainage ditches and dams, and runoff from logging has led to the significant change of bog composition and structure. Bog vegetation is extremely sensitive to minor changes in water levels and chemistry. Succession to more minerotrophic wetlands can occur as the result of increased alkalinity and raised water levels, which can cause the increased decomposition of acidic peats. Lowering of water tables from drainage can allow for tree and shrub encroachment into open bogs and the eventual succession to closed-canopy peatland. Dust-fall and atmospheric deposition from air pollution are particularly threats to bog systems in the southern portion of their range, where bogs are surrounded by cultivated land and close to industrial and urban centers. Eutrophication from pollution and altered hydrology can detrimentally impact bogs by generating conditions favorable for the establishment of invasive plant species. Particularly aggressive invasive species that may threaten the diversity and community structure of bogs include glossy buckthorn (*Rhamnus frangula*), narrow-leaved cat-tail (*Typha angustifolia*), hybrid cat-tail (*Typha x glauca*), reed canary grass (*Phalaris arundinacea*), and reed (*Phragmites australis*). At present, most of these invasive species appear to be restricted to the margins of bogs, where they occur in moats or ditches along roads and trails that border the community. Monitoring and control efforts to detect and remove invasive species before they become widespread are critical to the long-term viability of bog.

Variation

Subtle variations in overall species composition and physiognomy occur across this community's range along north-south and east-west climatic gradients. Bogs are common throughout the

northern Lower Peninsula and the Upper Peninsula and are less common south of the climatic tension zone. In the southern part of the Lower Peninsula, vegetation composition is shaped by greater minerotrophy and warmer climate. Tall shrubs are more prevalent in southern systems, as is the threat from invasive species.

Similar Natural Communities

Coastal plain marsh, intermittent wetland, inundated shrub swamp, muskeg, northern fen, patterned fen, poor conifer swamp, poor fen, prairie fen, rich tamarack swamp, and rich conifer swamp.

Relevant Literature

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For a full list of references used to create this description, please refer to the natural community abstract for bog.

Muskeg

Global/State Rank: G4G5/S3

Overview

Muskeg is a nutrient-poor peatland characterized by acidic, saturated peat, and scattered or clumped, stunted conifer trees set in a matrix of sphagnum mosses and ericaceous shrubs. Black spruce (*Picea mariana*) and tamarack (*Larix laricina*) are typically the most prevalent tree species. The community primarily occurs in large depressions on glacial outwash and sandy glacial lakeplains. Fire occurs naturally during periods of drought and can alter the hydrology, mat surface, and floristic composition of muskegs. Windthrow, beaver flooding, and insect defoliation are also important disturbance factors that influence species composition and structure.

Landscape Context

Muskegs primarily occur on broad, flat areas or mild depressions of glacial outwash and glacial lakeplains but can also be found in large depressions on pitted outwash and moraines. Peatlands occurring on former glacial lakebeds and drainageways tend to be more extensive than kettle peatlands, which are limited in area by the size of the glacial ice-block that formed the basin. Muskegs within large wetland complexes typically occur adjacent to other peatland communities, often grading into bog, patterned fen, poor fen, poor conifer swamp, and/or rich conifer swamp. More minerotrophic systems such as northern fen, northern shrub thicket, northern wet meadow, rich conifer swamp, and hardwood-conifer swamp can occur along the outer margins of muskegs where groundwater seepage from the adjacent uplands is prevalent. Muskegs frequently occur adjacent to lakes and meandering streams (usually less than third order), which often weave along the margins of muskegs and through the adjoining minerotrophic wetlands. Upland community types that often occur adjacent to muskegs include dry northern forest, dry-mesic northern forest, and mesic northern forest. Sandy ridges dominated by white pine, red pine, and/or jack pine often occur within peatland complexes, especially in the eastern Upper Peninsula where these low ridges represent former transverse dunes.

Soils

The organic soils of muskegs are composed of peat, which forms a continuous mat ranging in thickness from one to eight meters but is typically one to three meters deep and overlays sand. The depth of peat and soil moisture increases with peatland age and can vary within a site. Peat depth is typically greatest near the center of a peatland and decreases toward the margin or in areas with groundwater influence. The rooting zone within muskegs is quite shallow, typically confined to the uppermost 15 cm of the surface peat, where there is sufficient oxygen to maintain aerobic respiration. The surface peats of muskegs are dominated by saturated fibric peat, which is loosely compacted and spongy, contains partially decomposed sphagnum moss with fragments of wood and occasionally sedge, and like the surface water, is extremely acidic, cool, and characterized by low nutrient availability and low oxygen levels. Peat composition changes with depth and varies with the successional history of a given peatland. Generally, fiber content and hydraulic conductivity decrease with depth. Deep humidified peats can effectively seal basins and create a perched water table.

Natural Processes

Muskegs are ombrotrophic to weakly minerotrophic peatlands, receiving inputs of water and nutrients primarily from ion-poor precipitation. Saturated and inundated conditions inhibit

organic matter decomposition and allow for the accumulation of peat. Under cool, anaerobic, and acidic conditions, the rate of organic matter accumulation exceeds organic decay. Once sphagnum mosses become established on the peat mat, they maintain and enhance saturated, acidic, and cool conditions, which in turn promote continued peat development.

Development and expansion of peatlands occur via two distinct processes: lake-filling and paludification. Lake-filling occurs in small lakes with minimal wave action, where gradual peat accumulation results in the development of a peat mat that can fill the basin or occur as a floating mat or grounded mat. Paludification is the blanketing of terrestrial systems (often forests) by the overgrowth of sphagnum mosses and peatland vegetation. Paludified peatlands typically develop on flat areas, especially lakeplains, where peat builds vertically and spreads horizontally. The lateral expansion of peatland into forested systems can lead to the conversion to muskeg since thick sphagnum mats can limit tree establishment and growth. For both lake-filling and paludification, peat accumulates above the water table and the peatland becomes isolated from the influence of groundwater.

Once established, muskeg can persist for hundreds of years given stable hydraulic conditions and the lack of fire, which can burn the canopy and organic soils. Fire, which is an infrequent but important disturbance factor within peatlands, controls plant population dynamics by initiating and terminating succession. Estimates of fire return intervals for forested peatlands range widely from over a hundred to several hundred years in fire-prone landscapes to several hundred to over a thousand years for muskegs embedded within fire-protected landscapes. Fire severity and frequency in muskegs are closely related to climatic change and fluctuations in water level. Prolonged periods of drought and lowered water table can allow the surface peat to dry out sufficiently to burn, killing existing vegetation and occasionally exposing mineral soil. Low-severity surface fires in open peatlands can contribute to their maintenance by killing encroaching trees, promoting sprouting of ericaceous shrubs, and minimally impacting sphagnum moss cover.

Changes in the water and nutrient regimes of peatlands result in significant modification of species composition and abundance. Beaver, through their dam-building activities, can cause substantial hydrologic change to peatland systems, causing either flooding or the lowering of the water table depending on the location of the peatland in relation to the dam. Behind a beaver dam the water table is higher, while below it, drier conditions are generated. Short periods of flooding can cause needle chlorosis, necrotic needle tips, and decreased shoot and root growth of swamp conifers due to low oxygen concentration and nutrient availability in the rooting medium from water logging. Prolonged flooding of poor conifer swamps can result in the death of the canopy trees and the conversion to muskegs and bogs or even open systems dominated by marsh and fen vegetation. The lowering of the water table through beaver damming or climatic changes can result in the conversion of open peatlands to northern shrub thicket or poor conifer swamp.

Tree survival in muskegs is limited by windthrow, insects, and parasites. Trees growing in muskeg are particularly susceptible to windthrow because saturated sphagnum peat provides a poor substrate for anchoring trees. Small-scale wind disturbance, along with insect herbivory, contributes to the structural diversity of muskegs by generating moderate pit and mound microtopography, standing snags, and coarse woody debris that is quickly enveloped by sphagnum mosses. The plant parasite dwarf mistletoe (*Arceuthobium pusillum*) can increase the mortality of black spruce. Three insect defoliators are prevalent in peatlands: larch sawfly (*Pristiphora erichsonii*), larch casebearer (*Coleophora laricella*), and spruce budworm (*Choristoneura fumiferana*). Spruce budworm defoliates both black spruce and balsam fir (*Abies balsamea*) but tends to be more detrimental to the latter. Tamarack growing in peatlands often suffers from repeated defoliation by larch sawfly. Although a more recent arrival in Michigan, the

larch casebearer is beginning to cause heavy defoliation to tamarack, especially in the eastern and central Upper Peninsula.

Vegetation

Muskegs are characterized by a poor herbaceous layer dominated by sedges and a hummocky carpet of sphagnum moss, low ericaceous, evergreen shrubs, and widely scattered or clumped, stunted conifers. Floristically, muskegs are homogenous and of limited diversity, exhibiting remarkably uniform structure and composition across their wide range. The continuous moss layer of muskegs is typically dominated by sphagnum mosses, especially *Sphagnum angustifolium*, *S. centrale*, *S. fuscum*, *S. magellanicum*, and *S. recurvum*. Additional mosses can include *S. capillaceum*, *S. capillifolium*, *S. compactum*, *S. cuspidatum*, *S. papillosum*, *S. recurvum*, *S. rusowii*, and *Drepanocladus aduncus*. The hummock and hollow microtopography of muskeg allows for high levels of bryophyte diversity since individual species of sphagnum occur at specific elevations, exhibiting resource partitioning. The herbaceous layer of muskegs is depauperate and dominated by cyperaceous plants. Several sedges that are characteristic of muskegs include coastal sedge (*Carex exilis*), mud sedge (*C. limosa*), wiregrass sedge (*C. lasiocarpa*), few-flower sedge (*C. pauciflora*), few-seed sedge (*C. oligosperma*), and three-seeded sedge (*C. trisperma*). Additional graminoids found in muskegs include twig-rush (*Cladium mariscoides*), three-way sedge (*Dulichium arundinaceum*), narrow-leaved cotton-grass (*Eriophorum angustifolium*), sheathed cotton-grass (*E. spissum*), tawny cotton-grass (*E. virginicum*), rattlesnake grass (*Glyceria canadensis*), and white beak-rush (*Rhynchospora alba*). The following are prevalent muskeg herbs: bog aster (*Aster nemoralis*), goldthread (*Coptis trifolia*), fireweed (*Epilobium angustifolium*), fringed willow-herb (*E. ciliatum*), wild blue flag (*Iris versicolor*), bog buckbean (*Menyanthes trifoliata*), starry false Solomon's seal (*Smilacina stellata*), false mayflower (*S. trifolia*), starflower (*Trientalis borealis*), and common bog arrow-grass (*Triglochin maritima*). Insectivorous plants, including round-leaved sundew (*Drosera rotundifolia*), spoon-leaf sundew (*Drosera intermedia*), pitcher-plant (*Sarracenia purpurea*), and flat-leaved bladderwort (*Utricularia intermedia*), are common features of muskegs. The shrub layer of muskegs is dominated by low, ericaceous shrubs, with leatherleaf (*Chamaedaphne calyculata*) being the most prevalent species. In addition to leatherleaf, the following heath shrubs are important components of muskegs: bog rosemary (*Andromeda glaucophylla*), creeping snowberry (*Gaultheria hispidula*), wintergreen (*G. procumbens*), sheep-laurel (*Kalmia angustifolia*), bog laurel (*K. polifolia*), Labrador tea (*Ledum groenlandicum*), low sweet blueberry (*Vaccinium angustifolium*), Canada blueberry (*V. myrtilloides*), large cranberry (*V. macrocarpon*), and small cranberry (*V. oxycoccos*). The tall shrub layer of muskegs is less dense than the low shrub layer and is often restricted to the periphery of the community. Tall shrubs typical of muskegs include black chokeberry (*Aronia prunifolia*), mountain holly (*Nemopanthis mucronata*), pussy willow (*Salix discolor*), bog willow (*S. pedicellaris*), meadowsweet (*Spiraea alba*), steplebush (*S. tomentosa*), and wild-raisin (*Viburnum cassinoides*). Trees within muskegs are stunted, usually no taller than two to three meters, and widely scattered or clumped. Tree cover is typically between 10 and 25%. The most common are black spruce and tamarack, with jack pine (*Pinus banksiana*), white pine (*P. strobus*), and red pine (*P. resinosa*) as occasional associates.

Noteworthy Animals

In general, the population of animals is low in muskegs because of the low productivity of peatland plants, unpalatability of the vegetation, and high acidity of the peat. Bogs and muskegs provide important habitat for small mammals such as short-tailed shrew (*Blarina brevicauda*), beaver (*Castor canadensis*), meadow vole (*Microtus pennsylvanicus*), mink (*Mustela vison*), muskrat (*Ondatra zibethicus*), and masked shrew (*Sorex cinereus*). Both muskrats and beaver can

profoundly influence the hydrology of open peatlands. Muskrats create open water channels through the peat and beavers can cause substantial flooding through their dam-building activities.

Rare Plants

Carex heleonastes (Hudson Bay sedge, state endangered)

Carex wiegandii (Wiegand's sedge, state special concern)

Empetrum nigrum (black crowberry, state threatened)

Rubus acaulis (dwarf raspberry, state endangered)

Rare Animals

Alces americanus (moose, state special concern)

Ardea herodias (great blue heron, protected by the Migratory Bird Treaty Act of 1918)

Boloria freija (Freija fritillary, state special concern)

Boloria frigga (Frigga fritillary, state special concern)

Botaurus lentiginosus (American bittern, state special concern)

Canis lupus (gray wolf, federal endangered and state threatened)

Circus cyaneus (northern harrier, state special concern)

Clemmys guttata (spotted turtle, state threatened)

Coturnicops noveboracensis (yellow rail, state threatened)

Cryptotis parva (least shrew, state threatened)

Emydoidea blandingii (Blanding's turtle, state special concern)

Erebia discoidalis (red-disked alpine, state special concern)

Falcipectus canadensis (spruce grouse, state special concern)

Falco columbarius (merlin, state threatened)

Haliaeetus leucocephalus (bald eagle, state special concern)

Lynx canadensis (lynx, state endangered)

Pandion haliaetus (osprey, state special concern)

Picooides arcticus (black-backed woodpecker, state special concern)

Somatochlora incurvata (incurvate emerald, state special concern)

Sorex fumeus (smoky shrew, state threatened)

Tympanuchus phasianellus (sharp-tailed grouse, state special concern)

Williamsonia fletcheri (ebony boghaunter, state special concern)

Biodiversity Management Considerations

The primary mechanism for preserving muskegs is to maintain their hydrology. A serious threat to muskeg hydrology is posed by off-road vehicle traffic, which can significantly alter hydrology through rutting. Reducing access to peatland systems will help decrease detrimental impacts. Avoiding the construction of new roads that traverse peatlands will help prevent unintended hydrologic alteration. The installation and maintenance of culverts under roads passing through peatlands can avert flooding and drying. Resource managers operating in uplands and forested peatlands adjacent to muskegs should take care to minimize the impacts of management to hydrologic regimes, especially increased surface flow. This can be accomplished by establishing a no-cut buffer around muskegs and avoiding road construction and complete canopy removal in stands immediately adjacent to muskegs.

Anthropogenic disturbance has decreased the extent of peatlands and dramatically altered many occurrences. Turn-of-the-century logging of tamarack, black spruce, and cedar from peatland systems favored the conversion of forested peatlands to open, ombrotrophic bogs and muskegs. Historically, widespread slash fires followed logging, converting poor conifer swamp to open bogs or muskegs or destroying the peat and converting peatlands to mineral soil wetlands. Beginning in the 1920s, effective fire control reduced the acreage of fires ignited by humans or

lightning. In landscapes where frequent fire was the prevalent disturbance factor, fire suppression has led to the conversion of open bogs and muskegs to closed-canopy peatlands and the maintenance of closed-canopy poor conifer swamps. Peat mining and cranberry farming have degraded numerous peatlands throughout the region. In addition to direct impacts to vegetation, alteration of peatland hydrology from road building, creation of drainage ditches and dams, and runoff from logging and agriculture has led to significant changes in peatland composition and structure.

Peatland vegetation is extremely sensitive to minor changes in water levels and chemistry. Succession to more minerotrophic wetlands can occur as the result of increased alkalinity and raised water levels, which can cause the increased decomposition of acidic peats. Flooding of muskegs and poor conifer swamps can cause the death of canopy trees and the conversion of forested peatland to open wetlands. Flooding of poor conifer swamps can result in the conversion to muskeg. Roads and highways traversing through large peatland complexes, especially in the Upper Peninsula, have caused the blockage of drainage (impoundment of water) and the alteration of muskegs and poor conifer swamps to open peatlands. Conversely, lowering of water tables from drainage can allow for tree and shrub encroachment into open bogs and muskegs and the eventual succession to closed-canopy peatland. The dependence of muskegs on precipitation for nutrients and water makes them especially susceptible to acid rain and air pollution. Atmospheric deposition can contribute nitrogen, sulphur, calcium, and heavy metals to peatlands. Eutrophication from pollution and altered hydrology can detrimentally impact peatlands by generating conditions favorable for invasive plant species. Particularly aggressive invasive species that may threaten the diversity and community structure of muskeg include glossy buckthorn (*Rhamnus frangula*), narrow-leaved cat-tail (*Typha angustifolia*), hybrid cat-tail (*Typha x glauca*), reed canary grass (*Phalaris arundinacea*), and reed (*Phragmites australis*). At present, most of these invasive species appear to be restricted to the margins of muskegs, where they occur in moats or ditches along roads and trails that border the community. Monitoring and control efforts to detect and remove invasive species before they become widespread are critical to the long-term viability of muskeg.

Variation

Muskegs occurring on glacial lakeplains and outwash plains tend to be more extensive than those occurring in kettle depressions, which are limited in area by the size of the glacial ice-block that formed the basin.

Similar Natural Communities

Bog, northern fen, patterned fen, poor fen, poor conifer swamp, rich tamarack swamp, and rich conifer swamp.

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For a full list of references used to create this description, please refer to the natural community abstract for muskeg.

SHRUB WETLAND COMMUNITIES

Northern Shrub Thicket

Global/State Rank: G4/S5

Overview

Northern shrub thicket is a shrub-dominated wetland located north of the climatic tension zone, typically occurring along streams, but also adjacent to lakes and beaver floodings. The saturated, nutrient-rich, organic soils are composed of sapric peat or less frequently mineral soil, typically with medium acid to neutral pH. Succession to closed-canopy swamp forest is slowed by fluctuating water tables, beaver flooding, and windthrow. Northern shrub thickets are overwhelmingly dominated by tag alder (*Alnus rugosa*).

Landscape Context

Northern shrub thicket occurs principally along streams, beaver floodings, lakeshores, and rivers within glacial outwash channels and less frequently within ice-contact topography and coarse-textured end moraines. Sites are characterized by little to no slope, can range from small pockets to extensive acreages, and are often a narrow band or zone of 20 to 30 meters within a larger wetland complex. The community typically grades into northern wet meadow along stream and lake margins, and along the margins of uplands it often borders swamp forest.

Soils

The soils of northern shrub thicket are wet to moist, nutrient-rich, well-decomposed sapric peat, or occasionally mineral soil. The pH ranges widely from alkaline to acidic with medium acidity being the most prevalent condition. The soils are characterized by high nutrient levels due to the nitrogen-fixing ability of alder. Northern shrub thickets are non-stagnant wetlands with high levels of dissolved oxygen and soil nitrogen. Soils range from poorly drained to well drained, with most sites remaining saturated throughout the growing season. The community is typically flooded in spring.

Natural Processes

Northern shrub thickets can become established following severe disturbance of swamp forests or through shrub establishment in open wetlands such as northern wet meadow. Flooding (i.e., from beaver or fluvial processes), fire, disease, and windthrow can result in sufficient mortality of the swamp forest overstory to allow for the complete opening of the forest canopy and the expansion of alder through establishment of seedlings or stump sprouting. Following canopy release, alder can form dense, impenetrable thickets that retard or prevent tree establishment. Within open wetlands, alder and associated shrubs can become established following alteration in the fire or hydrologic regime. Prolonged periods without fire, an absence of beaver flooding, or the lowering of the water table allows for shrub encroachment into open wetlands and conversion to northern shrub thicket. Once established, northern shrub thicket can persist if disturbance factors prevent tree establishment and growth. Windthrow, beaver herbivory, beaver flooding, seasonal flooding, and fire can all limit tree establishment and survival. Alder's capacity to stump-sprout following flooding, fire, and herbivory allow it to persist after these disturbances. However, long-term flooding as a result of beaver damming can eliminate alder as well as other woody species. Northern shrub thicket typically succeeds to closed-canopy swamp forest in the absence of disturbance factors that prevent tree establishment and survival or cause prolonged flooding.

Vegetation

Northern shrub thickets are characterized by an overwhelming dominance of tag alder, which forms dense, often monotypic thickets with canopy coverage ranging between 40 and 95% and stand height typically ranging from one to three meters. The community exhibits a high degree of floristic homogeneity due to the dominance of alder. Floristic diversity is usually correlated with the degree of shrub canopy closure, with higher levels of diversity occurring in more open sites. The understory, which is comprised of species from both meadow and forest, is dominated by an array of short shrubs, forbs, grasses, sedges, and ferns. Prevalent herbs of northern shrub thickets include: swamp aster (*Aster puniceus*), marsh marigold (*Caltha palustris*), marsh bellflower (*Campanula aparinoides*), joe-pye-weed (*Eupatorium maculatum*), common boneset (*E. perfoliatum*), rough bedstraw (*Galium asprellum*), jewelweed (*Impatiens capensis*), wild blue flag (*Iris versicolor*), northern bugleweed (*Lycopus uniflorus*), wild mint (*Mentha arvensis*), monkey-flower (*Mimulus ringens*), common skullcap (*Scutellaria galericulata*), mad-dog skullcap (*S. lateriflora*), golden ragwort (*Senecio aureus*), Canada goldenrod (*Solidago canadensis*), late goldenrod (*S. gigantea*), rough goldenrod (*S. rugosa*), skunk cabbage (*Symplocarpus foetidus*), and purple meadow rue (*Thalictrum dasycarpum*). Characteristic ferns and fern allies include common horsetail (*Equisetum arvense*), sensitive fern (*Onoclea sensibilis*), cinnamon fern (*Osmunda cinnamomea*), royal fern (*O. regalis*), and marsh fern (*Thelypteris palustris*). Short shrubs include sweet gale (*Myrica gale*), marsh cinquefoil (*Potentilla palustris*), wild black currant (*Ribes americanum*), swamp dewberry (*Rubus hispida*), dwarf raspberry (*R. pubescens*), wild red raspberry (*R. strigosus*), and meadowsweet (*Spiraea alba*). Where alder does not form a monospecific shrub layer, associates of the tall shrub layer can include black chokeberry (*Aronia prunifolia*), bog birch (*Betula pumila*), silky dogwood (*Cornus amomum*), red-osier dogwood (*C. stolonifera*), winterberry (*Ilex verticillata*), Bebb's willow (*Salix bebbiana*), pussy willow (*S. discolor*), sandbar willow (*S. exigua*), slender willow (*S. petiolaris*), wild-raisin (*Viburnum cassinoides*), and highbush-cranberry (*V. opulus* var. *americanum*). Scattered trees and tree saplings are often found invading northern shrub thickets. Typical tree species include balsam fir (*Abies balsamea*), red maple (*Acer rubrum*), black ash (*Fraxinus nigra*), tamarack (*Larix laricina*), black spruce (*Picea mariana*), balsam poplar (*Populus balsamifera*), quaking aspen (*P. tremuloides*), and northern white-cedar (*Thuja occidentalis*).

Noteworthy Animals

The leaves and twigs of alder provide important food resources for a wide array of mammals including moose (*Alces americanus*, state special concern), muskrat (*Ondatra zibethicus*), beaver (*Castor canadensis*), cottontail rabbit (*Sylvilagus floridanus*), and snowshoe hare (*Lepus americanus*). Beaver build dams and lodges with tag alder twigs. In addition, beaver activity can strongly influence establishment, maintenance, expansion, and conversion of northern shrub thicket. The buds and seeds of alder are eaten by a diversity of birds. Songbirds feed on alder seeds, and American woodcock (*Philohela minor*) and ruffed grouse (*Bonasa umbellus*) eat the buds and catkins. Thickets of alder provide important cover for species such as white-tailed deer (*Odocoileus virginianus*), river otter (*Lutra canadensis*), and mink (*Mustela vison*). Gray wolf (*Canis lupus*, federal endangered and state threatened) and lynx (*Lynx canadensis*, state endangered) also utilize shrub thicket habitat.

Rare Plants

Equisetum telmateia (giant horsetail, presumed extirpated from Michigan)
Listera auriculata (auricled twayblade, state special concern)
Lonicera involucreta (black twinberry, state threatened)
Mimulus guttatus (western monkey-flower, state special concern)
Silene nivea (evening campion, state endangered)
Stellaria crassifolia (fleshy stitchwort, state endangered)

Rare Animals

Alces americanus (moose, state special concern)
Ardea herodias (great blue heron, protected by the Migratory Bird Treaty Act of 1918)
Canis lupus (gray wolf, federal endangered and state threatened)
Emydoidea blandingii (Blanding's turtle, state special concern)
Glyptemys insculpta (wood turtle, state special concern)
Haliaeetus leucocephalus (bald eagle, state special concern)
Lynx canadensis (lynx, state endangered)
Oncocnemis piffardi (three-striped oncocnemis, state special concern)
Pandion haliaetus (osprey, state special concern)
Pseudacris maculata (boreal chorus frog, state special concern)
Sistrurus c. catenatus (eastern massasauga, federal candidate species and state special concern)

Biodiversity Management Considerations

In the Great Lakes region, northern shrub thicket is a widespread community type that has dramatically increased in acreage from its historical extent due to anthropogenic disturbance. The increase in northern shrub thicket is the result of extensive logging of swamp forests, alteration of hydrologic regimes, and fire suppression. Turn-of-the-century logging of conifer swamp resulted in the conversion of many forested swamps to northern shrub thicket in the Great Lakes region. In areas historically dominated by open, herbaceous wetlands (i.e., northern wet meadow, northern fen, emergent marsh), tiling, ditching, and road building have lowered the water table, resulting in their conversion to shrub-dominated wetlands. As the result of fire suppression and low beaver populations, many open wetlands have converted to shrub-dominated wetlands. Northern shrub thicket has also been maintained and expanded by wildlife management geared toward providing favorable habitat for game species of early-successional habitat, particularly white-tailed deer, American woodcock, and ruffed grouse.

Alder swamps contribute significantly to the overall biodiversity of northern Michigan by providing habitat to a wide variety of plant and animal species including several rare species. However, northern shrub thickets have replaced many rare and declining wetland communities such as rich conifer swamp and northern fen. Where shrub encroachment threatens to convert less common open wetlands to shrub-dominated systems, prolonged flooding, repeated prescribed fires, mowing, or herbicide application to cut shrub stumps can be employed to maintain open conditions. On sites in which northern shrub thicket is succeeding to swamp forest, allowing succession to proceed unhindered will result in increased acreage of less common swamp communities. Northern shrub thicket can be maintained by cutting overstory trees and where feasible, mild intensity burning can be used to encourage alder regeneration. While northern shrub thicket has replaced many declining and rare communities, it does provide important ecosystem services, protecting water quality by assimilating nutrients, trapping sediment, and retaining stormwater and floodwater.

Monitoring and control efforts to detect and remove invasive species are critical to the long-term viability of northern shrub thicket and associated wetlands. Particularly aggressive invasive species that threaten the diversity and community structure include glossy buckthorn (*Rhamnus frangula*), multiflora rose (*Rosa multiflora*), purple loosestrife (*Lythrum salicaria*), narrow-leaved cat-tail (*Typha angustifolia*), hybrid cat-tail (*Typha xglauca*), reed canary grass (*Phalaris arundinacea*), and reed (*Phragmites australis*).

Variation

Community size, shape, and species composition can vary significantly, depending on landscape context. Generally, occurrences on poorly drained, level outwash plains and lakeplains are larger than those associated with narrow outwash channels and stream corridors.

Similar Natural Communities

Floodplain forest, Great Lakes marsh, hardwood-conifer swamp, inundated shrub swamp, northern fen, northern hardwood swamp, northern wet meadow, poor conifer swamp, rich conifer swamp, southern shrub-carr, and wooded dune and swale complex.

Relevant Literature

- Cohen, J.G. 2005. Natural community abstract for northern shrub thicket. Michigan Natural Features Inventory, Lansing, MI. 8 pp.
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- Parker, G.R., and G. Schneider. 1974. Structure and edaphic factors of an alder swamp in northern Michigan. *Canadian Journal of Forestry Research* 4: 499-508.
- Van Deelen, T.R. 1991. *Alnus rugosa*. In Fire Effects Information System [online]. USDA, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (producer). Available: <http://www.fs.fed.us/database/feis/> (Accessed: May 20, 2004.)

For a full list of references used to create this description, please refer to the natural community abstract for northern shrub thicket.

Southern Shrub-Carr

Global/State Rank: GU/S5

Overview

Southern shrub-carr is a moderate to long persistent successional shrub community dominated by willows (*Salix* spp.), dogwoods (i.e., *Cornus stolonifera*, *C. foemina*, and *C. amomum*), winterberry (*Ilex verticillata*), and bog birch (*Betula pumila*). This community is successional intermediate among a variety of open, herbaceous wetlands (i.e., southern wet meadow, prairie fen, wet-mesic prairie, and lakeplain wet-mesic prairie) and forested wetlands such as rich tamarack swamp and southern hardwood swamp. It typically occurs on saturated, organic soil and is characterized by fluctuating water levels and poor drainage conditions. Southern shrub-carr is found primarily south of the climatic tension zone in southern Lower Michigan and is frequent in other Midwestern states such as Illinois, Indiana, Iowa, Minnesota, and Wisconsin. North of the climatic tension zone, wet-ground, tall shrub communities are typically dominated by tag alder (*Alnus rugosa*) and are classified as northern shrub thicket.

Landscape Context

Shrub-carr typically occurs as bands along streams, rivers, and lakes, on glacial lakeplains and outwash plains, and within outwash channels and depressions on ice-contact topography and moraines. Sites are characterized by little to no slope and can range from small pockets or narrow bands to extensive acreages. The community often occurs as part of a large wetland complex, where it may form a transition zone between open herbaceous wetlands and forested wetlands.

Soils

Shrub-carr is usually found on seasonally inundated, saturated organic soils such as sapric peat with neutral to mildly alkaline pH and the capacity to retain excessive water.

Natural Processes

Shrub-carr typically originates when shrub species invade fens, sedge meadows, wet prairies, and prairie fens following an alteration to the fire or hydrologic regime. Fire suppression and events that lower local or regional water tables allow shrubs to colonize open wetlands and assume dominance. Conversely, beaver-induced flooding limits shrub and tree encroachment and maintains open conditions of meadows and fens. The extent of southern shrub-carr in Michigan has greatly expanded since European settlement due to widespread fire suppression, hydrologic alterations, and a dramatic decline in the beaver population.

Once shrub-carr has become established, frequent disturbance allows it to persist rather than succeed to a forested swamp community. Beaver herbivory and windthrow can limit tree longevity and help maintain southern shrub-carr. Given that shrub-carr occurs along streams, rivers, and lake edges, the community is well adapted to seasonal hydrologic cycling. However, prolonged flooding can kill shrubs and cause conversion to shallow ponds, emergent marsh, southern wet meadow, prairie fen, or wet prairie depending on landscape position, soils, and depth and duration of flooding. In the absence of flooding and fire, southern shrub-carr typically succeeds to closed-canopy swamp forest, such as southern hardwood swamp and rich tamarack swamp.

Vegetation

There are commonly three distinct vegetation layers in a southern shrub-carr community. The most pronounced is the shrub layer, which typically exhibits little stratification or layering, and ranges in height from 1.5 to 5.5 m (5 to 18 ft, average 2.6 m or 8.6 ft). Common species in the shrub layer may include dogwoods (*C. amomum*, *Cornus foemina*, and *C. stolonifera*), willows (*Salix bebbiana*, *S. discolor*, *S. exigua*, *S. petiolaris*, *S. serissima*, and *S. eriocephala*), winterberry (*Ilex verticillata*), elderberry (*Sambucus canadensis*), swamp rose (*Rosa palustris*), poison sumac (*Toxicodendron vernix*), smooth highbush blueberry (*Vaccinium corymbosum*), American hazelnut (*Corylus americana*), black chokeberry (*Aronia prunifolia*), and nannyberry (*Viburnum lentago*). The shrub layer can be dense to patchy depending on the successional state and local site conditions within the community. The second vegetation layer is an intermediate layer of tall herbaceous plants and short shrubs and can include sedges (*Carex stricta*, *C. comosa*, *C. hystericina*, and *C. lacustris*), water plantain (*Alisma plantago-aquatica*), swamp milkweed (*Asclepias incarnata*), bluejoint grass (*Calamagrostis canadensis*), water hemlock (*Cicuta maculata*), water horsetail (*Equisetum fluviatile*), marsh fleabane (*Erigeron philadelphicus*), common boneset (*Eupatorium perfoliatum*), rattlesnake grass (*Glyceria canadensis*), softstem bulrush (*Schoenoplectus tabernaemontani*), bulrush (*Scirpus pendulus*), Canada goldenrod (*Solidago canadensis*), marsh fern (*Thelypteris palustris*), bog birch (*Betula pumila*), swamp gooseberry (*Ribes hirtellum*), meadowsweet (*Spiraea alba*), raspberries (*Rubus* spp.), and shrubby cinquefoil (*Potentilla fruticosa*). A third vegetative layer of smaller herbaceous plants may also occur and include species such as bedstraw (*Galium* spp.), clearweed (*Pilea pumila*), northern bugle weed (*Lycopus uniflorus*), Canada mayflower (*Maianthemum canadensis*), and marsh bellflower (*Campanula aparinoides*). Overall, the vegetation of shrub-carrs is highly variable due to frequent disturbances and small-scale temporal and spatial differences in microtopography, soil moisture, and nutrient availability.

Noteworthy Animals

Because many of the prevalent shrubs produce fruit in late summer, shrub-carr provides important foraging habitat for migrating and over-wintering songbirds. The community provides nesting habitat for the common yellowthroat (*Geothlypis trichas*). American woodcock (*Philohela minor*) and ruffed grouse (*Bonasa umbellus*) also utilize the community. Large ant mounds, particularly those built by members of the genus *Formica*, have been observed in shrub-carr and indicate that a site was formerly an open herbaceous wetland prior to shrub colonization.

Rare Plants

Hypericum sphaerocarpum (round-fruited St. John's-wort, state endangered)

Lygodium palmatum (climbing fern, state endangered)

Pycnanthemum muticum (broad-leaved mountain mint, state threatened)

Rare Animals

Acris blanchardi (Blanchard's cricket frog, state threatened)

Catocala illecta (magdalen underwing, state special concern)

Clemmys guttata (spotted turtle, state threatened)

Erynnis p. persius (Persius duskywing, state threatened)

Gomphus quadricolor (rapids clubtail, state special concern)

Hemileuca maia (barrens buckmoth, state special concern)

Lanius ludovicianus migrans (migrant loggerhead shrike, state endangered)

Neonympha m. mitchellii (Mitchell's satyr, federal/state endangered)

Nycticorax nycticorax (black-crowned night-heron, state special concern)

Papaipema speciosissima (regal fern borer, state special concern)

Sistrurus c. catenatus (eastern massasauga, federal candidate species and state special concern)

Terrapene c. carolina (eastern box turtle, state special concern)
Williamsonia fletcheri (ebony boghaunter, state special concern)

Biodiversity Management Considerations

Southern shrub-carr is a widespread community type in the Great Lakes region and likely occupies a greater percentage of wetland acreage today than it did in the 1800s due to fire suppression and alterations to hydrologic regimes. The community contributes significantly to the overall biodiversity of southern Michigan by providing habitat to a wide variety of plant and animal species including several rare species. However, southern shrub-carr has replaced many rare and declining wetland communities such as prairie fen, southern wet meadow, and rich tamarack swamp. Where shrub encroachment threatens to convert less common open wetlands to shrub-dominated systems, prolonged flooding, repeated prescribed fires, mowing, or herbicide application to cut shrub stumps can be employed to maintain open conditions. On sites that are succeeding to swamp forest, allowing succession to proceed unhindered will favor an increase of less common swamp systems. Southern shrub-carr can be maintained by cutting tree species. While southern shrub-carr has replaced many declining and rare communities, it does provide important ecosystem services, protecting water quality by assimilating nutrients, trapping sediment, and retaining storm water and floodwater.

Invasive species that threaten to reduce the diversity and alter the community structure of southern shrub-carr include glossy buckthorn (*Rhamnus frangula*), common buckthorn (*R. cathartica*), multiflora rose (*Rosa multiflora*), purple loosestrife (*Lythrum salicaria*), narrow-leaved cat-tail (*Typha angustifolia*), hybrid cat-tail (*Typha xglauca*), reed (*Phragmites australis*), and reed canary grass (*Phalaris arundinacea*). Monitoring for these and other invasive species followed by prompt and sustained control efforts will help protect the ecological integrity of southern shrub-carr and adjacent natural communities.

Variation

Community size, shape, and species composition can vary significantly, depending on landscape context. Generally, occurrences on poorly drained, level outwash plains and lakeplains are larger than those associated with narrow outwash channels and stream corridors.

Similar Natural Communities

Prairie fen, southern wet meadow, northern shrub thicket, inundated shrub swamp, southern hardwood swamp, and rich tamarack swamp.

Relevant Literature

- Bingham, M.T. 1945. The flora of Oakland Co., Michigan. Cranbrook Institute of Science, Bulletin 22. 155 pp.
- Curtis, J.T. 1959. The vegetation of Wisconsin. University of Wisconsin Press, Madison, WI. 657 pp.
- Eggers, S.D., and D.M. Reed. 1997. Wetland plants and plant communities of Minnesota and Wisconsin. U.S. Army Corps of Engineers, St. Paul, MN. 263 pp.
- White, K.L. 1965. Shrub-carrs of southeastern Wisconsin. Ecology 46(3): 286-304.

Inundated Shrub Swamp

Global/State Rank: G4/S3

Overview

Inundated shrub swamp is a shrub-dominated community characterized by poor drainage, nearly continuous inundation or saturation, and dominance by buttonbush (*Cephalanthus occidentalis*). The community typically exhibits a scattered shrub-dominated overstory and sparse herbaceous cover.

Landscape Context

This community occupies kettleholes in ice-contact topography and moats around bogs, and is occasionally found in wetland depressions on outwash and sandy lakeplains. Inundated shrub swamp typically occurs in isolated depressions (i.e., ice-block depressions) surrounded by forested uplands of mesic southern forest, dry-mesic southern forest, or dry southern forest.

Soils

Soils are typically shallow muck over gleyed clay, silty clay, or sandy clay. Soil pH ranges from strongly acid to moderately alkaline, with organic portions of the soil profile being more acidic than mineral portions. Although soil typically remains inundated throughout the year due to the underlying impermeable clay, the upper soil layers may become dry in mid to late summer and during periods of persistent drought.

Natural Processes

Inundated shrub swamp is successional intermediate between open emergent marsh and swamp forest. The community becomes established as shrubs tolerant of prolonged, inundated conditions invade open wetlands. Frequent disturbances such as seasonal hydrologic cycling and prolonged flooding allow inundated shrub swamp to persist rather than succeed to swamp forest. Water often pools for prolonged periods of time due to the impermeable clay layer in the soil profile, which limits tree establishment and growth. Additionally, beaver herbivory can limit tree longevity and help maintain inundated shrub swamp. While major flood events and beaver flooding kill invading trees, contributing to the persistence of inundated shrub swamp, extended periods of drought or hydrologic changes that lower the water table foster tree establishment and conversion to swamp forest.

Vegetation

Inundated shrub swamps are characterized by dominance of buttonbush, which typically represents more than 50% of the shrub cover. Buttonbush is well adapted to fluctuating water tables, constant inundation, and a broad range of pH levels, allowing it to outcompete many other tree and shrub species. Research suggests a minimum water depth of 0.5 m (20 in) is needed for successful maintenance of buttonbush populations, and the species is typically restricted to emergent or inundated zones. Although buttonbush responds favorably to increased light levels, high light levels are not critical for its establishment.

In addition to buttonbush, other common species in the shrub layer of inundated shrub swamps include willows (i.e., *Salix bebbiana* and *S. discolor*), red-osier dogwood (*Cornus stolonifera*), silky dogwood (*C. amomum*), winterberry (*Ilex verticillata*), black chokeberry (*Aronia prunifolia*), swamp dewberry (*Rubus hispidus*), and swamp rose (*Rosa palustris*). Shrub cover can range from 40 to 90%, with an average of 70%. Often a scattered tree canopy is also present and may include maples (i.e., *Acer rubrum*, *A. saccharinum*, and *A. saccharum*), yellow birch (*Betula alleghaniensis*), musclewood (*Carpinus caroliniana*), ashes (i.e., *Fraxinus nigra* and *F. pennsylvanica*), black walnut (*Juglans nigra*), oaks (i.e., *Quercus bicolor* and *Q. palustris*), black willow (*Salix nigra*), and American elm (*Ulmus americana*). In a

survey of 13 inundated shrub swamps in southern Michigan, tree overstory cover ranged from 5 to 60%, with an average cover of 23%.

Although the amount of ground cover can vary greatly both within and among inundated shrub swamps, the herbaceous layer is typically fairly sparse due to frequent and prolonged flooding. The ground flora may contain species such as short-awned foxtail (*Alopecurus aquatilis*), swamp milkweed (*Asclepias incarnata*), common beggar ticks (*Bidens frondosus*), false nettle (*Boehmeria cylindrica*), sedges (*Carex stricta*, *C. intumescens*, *C. rostrata*, *C. radiata*, *C. lacustris*, and *C. crinita*), water hemlock (*Cicuta bulbifera*), goldthread (*Coptis trifolia*), spinulose woodfern (*Dryopteris carthusiana*), jewelweed (*Impatiens capensis*), southern blue flag (*Iris virginica*), rattlesnake grass (*Glyceria canadensis*), small duckweed (*Lemna minor*), common water horehound (*Lycopus americanus*), northern bugle weed (*L. uniflorus*), tufted loosestrife (*Lysimachia thyriflora*), Canada mayflower (*Maianthemum canadense*), sensitive fern (*Onoclea sensibilis*), cinnamon fern (*Osmunda cinnamomea*), Virginia chain-fern (*Woodwardia virginica*), reed canary grass (*Phalaris arundinacea*), clearweed (*Pilea pumila*), puccinellia (*Puccinellia pallida*), mad-dog skullcap (*Scutellaria lateriflora*), water parsnip (*Sium suave*), bur-reeds (*Sparganium* spp.), skunk cabbage (*Symplocarpus foetidus*), and starflower (*Trientalis borealis*).

Noteworthy Animals

The community provides critical breeding habitat to amphibians and aquatic invertebrates. Snakes utilize the community for foraging habitat. In particular, the northern water snake and copperbelly watersnake (*Nerodia erythrogaster neglecta*, federal threatened and state endangered) feed on frogs that utilize the inundated shrub swamp.

Rare Plants

Wolffia papulifera (water-meal, state threatened)

Rare Animals

Acris blanchardi (Blanchard's cricket frog, state threatened)

Ambystoma texanum (smallmouth salamander, state endangered)

Clemmys guttata (spotted turtle, state threatened)

Emydoidea blandingii (Blanding's turtle, state special concern)

Heteropacha rileyana (Riley's lappet moth, state special concern)

Heterocampa subrotata (small heterocampa, state special concern)

Nerodia erythrogaster neglecta (copperbelly water snake, federal threatened and state endangered)

Nycticorax nycticorax (black-crowned night-heron, state special concern)

Papaipema speciosissima (regal fern borer, state special concern)

Terrapene c. carolina (eastern box turtle, state special concern)

Williamsonia fletcheri (ebony boghaunter, state special concern)

Biodiversity Management Considerations

Anthropogenic hydrologic alterations caused by dams, road-building, draining and ditching, agriculture, logging, and urban development can stabilize or permanently change water tables, thereby threatening the ecological integrity of inundated shrub swamps. Additionally, incompatible land uses in the surrounding landscape can result in excess nutrients, sediments, and chemicals entering the community, where they can alter nutrient cycles and species composition. A well-established buffer of natural communities helps maintain natural hydrology and reduce nutrient-loading.

Invasive species documented from inundated shrub swamps in Michigan include glossy buckthorn (*Rhamnus frangula*), multiflora rose (*Rosa multiflora*), autumn olive (*Elaeagnus umbellata*), reed canary grass, garlic mustard (*Alliaria petiolata*), Canada thistle (*Cirsium*

arvense), moneywort (*Lysimachia nummularia*), curly dock (*Rumex crispus*), horse nettle (*Solanum carolinense*), and bittersweet nightshade (*Solanum dulcamara*). Given the potential for invasive species to outcompete native vegetation and alter community structure, monitoring and control efforts to detect and remove invasive species are a crucial component of protecting high-quality inundated shrub swamp communities.

Variation

Community size, basin morphology, presence and depth of water, and species composition can all vary significantly among inundated shrub swamps, even where they occur in proximity to one another.

Similar Natural Communities

Emergent marsh, northern shrub thicket, and southern shrub-carr.

Relevant Literature

- Faber-Langendoen, D., and S.J. Dina. 1987. Growth responses of *Cephalanthus occidentalis* L. (buttonbush) to varying light levels and flooding. Transactions of the Missouri Academy of Science 21. Pp. 55-62.
- Faber-Langendoen, D., and P.F. Maycock. 1989. Community patterns and environmental gradients of buttonbush, *Cephalanthus occidentalis*, ponds in lowland forests of southern Ontario. Canadian Field-Naturalist 103: 479-485.
- Faber-Langendoen, D., ed. 2001. Plant communities of the Midwest: Classification in an ecological context. Association for Biodiversity Information, Arlington, VA. 61 pp. + appendix (705 pp.).
- Kost, M.A., Y.M. Lee, J.G. Lee, and J.G. Cohen. 2006. Habitat characterization and evaluation of community types utilized by copperbelly watersnake (*Nerodia erythrogaster neglecta*) in Michigan and northern Ohio. Michigan Natural Features Inventory Report No. 2006-02, Lansing, MI. 20 pp. + appendices.
- Tyrell, L.E. 1987. A floristic survey of buttonbush swamps in Gahanna Woods State Nature Preserve, Franklin County, Ohio. Michigan Botanist 26(1): 29-37.

For a full list of references used to create this description, please refer to the natural community abstract for inundated shrub swamp.

FORESTED WETLAND COMMUNITIES

Poor Conifer Swamp

Global/State Rank: G4/S4

Overview

Poor conifer swamp is a nutrient-poor, forested peatland characterized by acidic, saturated peat, and the prevalence of coniferous trees, sphagnum mosses, and ericaceous shrubs. This system is found predominantly north of the climatic tension zone, and much less frequently in southern Lower Michigan. The community occurs in depressions in glacial outwash and sandy glacial lakeplains and in kettles on pitted outwash and depressions on moraines. Fire occurs naturally during drought periods and creates even-aged, often monospecific, stands of black spruce (*Picea mariana*). Windthrow, beaver flooding, and insect defoliation are also important disturbance factors influencing species composition and structure.

Landscape Context

Poor conifer swamps occur in depressions on pitted outwash and moraines and on flat areas or shallow depressions in glacial outwash and glacial lakeplains. Peatlands occurring on former glacial lakebeds and drainageways tend to be more extensive than kettle peatlands, which are limited in area by the size of the glacial ice-block that formed the basin. Poor conifer swamps within large wetland complexes typically occur adjacent to other peatland communities, often grading into bog, poor fen, muskeg, patterned fen, and/or rich conifer swamp. More minerotrophic systems such as northern fen, prairie fen, shrub thicket, wet meadow, rich conifer swamp, hardwood-conifer swamp, southern hardwood swamp, and rich tamarack swamp can occur along the outer margins of poor conifer swamps where groundwater seepage from the adjacent uplands is prevalent. Poor conifer swamps often occur adjacent to lakes and meandering streams (usually less than third order). Poor conifer swamp can also occur in the first bottom of floodplain valleys in backswamps where over-the-bank flooding from the river is infrequent and organic matter can accumulate. A wide array of upland community types can occur adjacent to poor conifer swamp; some of the more frequent neighboring upland systems include dry northern forest, dry-mesic northern forest, and mesic northern forest.

Soils

The organic soils of poor conifer swamps are composed of peat, which forms a continuous mat that can be as little as 15 cm (6 in) deep but is often at least 40 cm (16 in) deep. The rooting zone within poor conifer swamps is typically quite shallow, confined to the upper 15 cm (6 in) of the surface peat. Depth of peat and soil moisture vary within a site. Peat depth is typically greatest near the center of a peatland and decreases toward the peatland margin or in areas with groundwater influence. The surface peats of poor conifer swamps are dominated by saturated fibric peat, which is loosely compacted and spongy, contains partially decomposed sphagnum moss with fragments of wood and occasionally sedge, and like the surface water, is extremely acidic, cool, and characterized by low nutrient availability and oxygen levels.

Natural Processes

Poor conifer swamps are poorly drained ombrotrophic to weakly minerotrophic peatlands, receiving inputs of water and nutrients primarily from ion-poor precipitation. Saturated and inundated conditions inhibit organic matter decomposition and allow for the accumulation of

peat. Under cool, anaerobic, and acidic conditions, the rate of organic matter accumulation exceeds organic decay. Once sphagnum mosses become established on the peat mat, they maintain and enhance saturated, acidic, and cool conditions, which in turn promote continued peat development. Development and expansion of peatlands occur via two distinct processes: lake-filling and paludification. Lake-filling occurs in small lakes with minimal wave action, where gradual peat accumulation results in the development of a peat mat that can fill the basin or occur as a floating mat or grounded mat. Succession in lake-filled peatlands typically proceeds from lake to marsh to fen to bog to poor conifer swamp. Paludification is the blanketing of terrestrial systems (often forests) by the overgrowth of peatland vegetation. Paludified peatlands typically develop on flat areas (typically lakeplain) where peat builds vertically and spreads horizontally. The lateral expansion of peatland into forested systems can result in an increase in the water table and acidity and subsequent decreases in soil temperatures, nutrient availability, decomposition rates, canopy cover, growth rates, and seedling establishment. Paludification also results in a shift in species composition, with swamp conifers, especially black spruce, becoming more prevalent. For both lake-filling and paludification, peat accumulates above the water table, isolating the peatland from groundwater influence.

Disturbance factors influencing poor conifer swamps include fire, flooding, windthrow, and insects. Fire, which is an infrequent but important disturbance factor within poor conifer swamps, controls tree population dynamics by initiating and terminating succession. Estimates of fire return intervals for forested peatlands range widely from over a hundred to several hundred years in fire-prone landscapes to several hundred to over a thousand years in fire-protected landscapes. Fire severity and frequency in poor conifer swamps are closely related to climatic change and fluctuations in water level. Prolonged periods of drought and a lowered water table can allow the surface peat to dry out and burn. When the surface peat burns, the fire releases organic matter from the peat, stimulates decay, slows peat accumulation, and exposes mineral soil. Fires within poor conifer swamps are typically stand-replacing crown fires that kill the majority of canopy trees. Fires in poor conifer swamps generate a flush of growth, first in ground layer taxa and ericaceous shrubs, and then in coniferous trees. Exposure of the mineral soil provides a suitable medium for the establishment and germination of swamp conifers.

Beaver, through their dam-building activities, can instigate substantial hydrologic change to peatland systems, either causing flooding or lowering the water table of poor conifer swamps depending on the location of the forest in relation to the dam. Prolonged flooding of poor conifer swamps can result in the death of canopy trees and the conversion of forested peatlands to bogs or even open systems dominated by marsh or fen vegetation. Roots of peatland trees are physiologically active near the surface and are quickly killed when the water table rises following flooding. Flooding typically causes tree mortality after approximately ten years but different tree species have different tolerances for flooding. Short periods of flooding can cause needle chlorosis, necrotic needle tips, and decreased shoot and root growth of swamp conifers due to low oxygen concentration and nutrient availability in the water-logged rooting medium. The lowering of the water table through beaver damming or climatic changes can also significantly affect the species composition and successional trajectory of poor conifer swamps. Lowering of a forested peatland's water table results in increased soil aeration, soil temperature, decomposition, nutrient availability, and consequently, increased tree growth. Lowered water tables can dramatically reduce the micro-scale heterogeneity that characterizes peatlands by eliminating the fine-scale gradients in pH, moisture, and nutrient availability associated with hummocks and hollows. In addition, long-term water table drawdown can cause the decomposition of the organic layer and the conversion of poor conifer swamp to a more minerotrophic forest type.

Trees growing in poor conifer swamps are particularly susceptible to windthrow because sphagnum peat provides a poor substrate for anchoring trees. The living roots of woody peatland plants occur in a shallow rooting zone, generally restricted to the uppermost few centimeters where there is sufficient oxygen to maintain aerobic respiration. The superficial rooting of trees and poor drainage result in numerous windthrows. Small-scale wind disturbance, along with insect herbivory, contributes to the structural diversity of poor conifer swamps, generating numerous snags, coarse woody debris, and gaps within the canopy. Poor conifer swamps, which often contain dense monospecific stands of trees, are inherently susceptible to epizootic attacks of insects and parasites. The plant parasite dwarf mistletoe (*Arceuthobium pusillum*) can increase the mortality of black spruce. Three insect defoliators are prevalent in peatlands: larch sawfly (*Pristiphora erichsonii*), larch casebearer (*Coleophora laricella*), and spruce budworm (*Choristoneura fumiferana*). Spruce budworm defoliates both black spruce and balsam fir but tends to be more detrimental to the latter. Tamarack growing in poor conifer swamps often suffers from repeated defoliation by larch sawfly. Although a more recent arrival in Michigan, the larch casebearer is beginning to cause heavy defoliation to tamarack, especially in the eastern and central Upper Peninsula.

Vegetation

Poor conifer swamps are characterized by a canopy of coniferous trees, low ericaceous, evergreen shrubs, a poor herbaceous layer, and a hummocky carpet of sphagnum moss. The canopy is often dominated by black spruce. Tamarack (*Larix laricina*) is also a frequent canopy dominant or codominant. Canopy associates include balsam fir (*Abies balsamea*), white pine (*Pinus strobus*), jack pine (*Pinus banksiana*), paper birch (*Betula papyrifera*), and American mountain ash (*Sorbus americana*). The shrub layer is dominated by low, ericaceous shrubs, with Labrador tea (*Ledum groenlandicum*) being the most prevalent. Additional heath shrubs include bog rosemary (*Andromeda glaucophylla*), leatherleaf (*Chamaedaphne calyculata*), creeping snowberry (*Gaultheria hispidula*), wintergreen (*G. procumbens*), huckleberry (*Gaylussacia baccata*), sheep-laurel (*Kalmia angustifolia*), bog laurel (*K. polifolia*), low sweet blueberry (*Vaccinium angustifolium*), Canada blueberry (*V. myrtilloides*), and small cranberry (*V. oxycoccos*). The tall shrub layer is less dense than the low shrub layer and is often restricted to the periphery of the swamp or adjacent to streams that may meander through the peatland. Tall shrubs include black chokeberry (*Aronia prunifolia*), wild-raisin (*Viburnum cassinoides*), and mountain holly (*Nemopanthus mucronata*). Stunted trees, especially black spruce and tamarack, may also occur within the understory. The herbaceous layer is species depauperate. Several characteristic sedges include wiregrass sedge (*Carex lasiocarpa*), bristly-stalked sedge (*C. leptalea*), few-flower sedge (*C. pauciflora*), few-seed sedge (*C. oligosperma*), and three-seeded sedge (*C. trisperma*), with the last two being most common. Additional graminoids include sheathed cotton-grass (*Eriophorum spissum*), tawny cotton-grass (*E. virginicum*), and wool-grass (*Scirpus cyperinus*). Additional prevalent ground flora include bluebead lily (*Clintonia borealis*), goldthread (*Coptis trifolia*), bunchberry (*Cornus canadensis*), fireweed (*Epilobium angustifolium*), wild blue flag (*Iris versicolor*), northern bugleweed (*Lycopus uniflorus*), Canada mayflower (*Maianthemum canadense*), false mayflower (*Smilacina trifolia*), and starflower (*Trientalis borealis*). Characteristic ferns include sensitive fern (*Onoclea sensibilis*), royal fern (*Osmunda regalis*), and Virginia chain-fern (*Woodwardia virginica*). Insectivorous plants, such as round-leaved sundew (*Drosera rotundifolia*) and pitcher-plant (*Sarracenia purpurea*), are occasional features of poor conifer swamps. The continuous moss layer of poor conifer swamps is typically dominated by sphagnum mosses, especially *Sphagnum angustifolium*, *S. capillifolium*, *S. fuscum*, *S. magellanicum*, and *S. recurvum*. Additional mosses can include *S. capillaceum*, *S. centrale*, *S. compactum*, *S. cuspidatum*, *S. papillosum*, *S. wulfianum*, and *Drepanocladus aduncus*. Shade beneath black spruce trees is conducive to the growth of feather moss (*Pleurozium schreberi*). Plant species diversity within poor conifer swamps is strongly correlated to the hummock-hollow

microtopography; each individual hummock in a peatland is in essence a miniature ecosystem with distinct gradients in water and substrate chemistry, soil moisture, aeration, and nutrients.

Noteworthy Animals

In general, animal diversity is low in poor conifer swamps because of the low productivity of peatland plants, the unpalatability of the vegetation, and the high acidity of the peat. Selective browsing by moose (*Alces americanus*, state special concern) can result in changes to poor conifer swamp floristic composition and structure. Beaver (*Castor canadensis*) can profoundly influence the hydrology of poor conifer swamp through their dam-building activities.

Rare Plants

Carex wiegandii (Wiegand's sedge, state special concern)
Empetrum nigrum (black crowberry, state threatened)
Luzula parviflora (small-flowered wood rush, state threatened)
Rubus acaulis (dwarf raspberry, state endangered)
Sarracenia purpurea f. heterophylla (yellow pitcher-plant, state threatened)

Rare Animals

Alces americanus (moose, state special concern)
Ardea herodias (great blue heron, protected by the Migratory Bird Treaty Act of 1918)
Canis lupus (gray wolf, federal endangered and state threatened)
Emydoidea blandingii (Blanding's turtle, state special concern)
Falci pennis canadensis (spruce grouse, state special concern)
Falco columbarius (merlin, state threatened)
Glyptemys insculpta (wood turtle, state special concern)
Haliaeetus leucocephalus (bald eagle, state special concern)
Lynx canadensis (lynx, state endangered)
Pandion haliaetus (osprey, state special concern)
Picoides arcticus (black-backed woodpecker, state special concern)
Sistrurus c. catenatus (eastern massasauga, federal candidate species and state special concern)
Tympanuchus phasianellus (sharp-tailed grouse, state special concern)

Biodiversity Management Considerations

When the primary conservation objective is to maintain biodiversity of poor conifer swamps, the best management strategy is to leave large tracts unharvested and allow natural processes (fire, beaver flooding, and insect defoliation) to operate unhindered and stochastically generate a range of successional stages. It is crucial to allow dead and dying wood to remain within these systems to become snags, stumps, and fallen logs. Within areas managed solely for biodiversity, resource practitioners should refrain from salvage harvesting following fire, wind, and insect disturbance. Salvage logging, especially following fire, can severely diminish nutrient pools and site productivity in addition to reducing structural heterogeneity.

Where poor conifer swamps are being actively managed, maintaining poor conifer swamps in different age-classes and stages of structural development at the landscape level will contribute to the preservation of regional biodiversity. Increasing old-growth and over-mature poor conifer swamps and their habitat characteristics can be accomplished by extending the rotation period of these systems. Long rotation periods (more than 100 years) are favorable for numerous species, such as epiphytic lichen and trunk foraging birds that depend on old, large trees. Within fire-prone landscapes, managers should consider using even-aged management, while in fire-resistant systems uneven-aged silviculture is more appropriate. Partial and selective cutting within poor conifer swamps has been suggested to simulate secondary disturbance such as windthrow.

However, these uneven-aged cutting techniques do not generate pit and mound microtopography and fail to leave behind the same volume of coarse wood generated by natural disturbance such as windthrow. Even-aged management of poor conifer swamps should be restricted to fire-prone landscapes, and timber rotations should reflect site-specific fire return intervals. A common misconception about even-aged management of forested peatlands is that clear-cuts or final harvests are surrogates for crown fires. Even-aged management within conifer swamps should strive to maintain patches of residual trees and numerous snags. Scattered seed trees and cone-bearing logging slash can provide an important source for natural regeneration. With both even-aged and uneven-aged management of forested peatlands, protecting the residual regeneration and seed trees and generating or preserving suitable sites for seedling establishment are critical. “Careful logging” is stressed by numerous researchers as a means of preserving advanced regeneration. Harvesters can avoid damage to residual trees by planning ahead of time where to travel, where to drop felled trees (directional felling), and where to process and pile the bucked logs. Impacts to peat soils can be minimized by using high-flotation tires or restricting operation in forested peatlands to winter when snow cover and frozen soils provide protection from rutting. Integral to the maintenance of forested peatlands is the preservation of hydrologic regimes. The installation and maintenance of culverts under roads passing through peatlands can avert flooding and drying.

In addition to direct impacts to vegetation, alteration of peatland hydrology due to road building, creation of drainage ditches and dams, and runoff from logging and agriculture has led to the significant changes in peatland composition and structure. Flooding of poor conifer swamps can cause the death of canopy trees and the conversion of forested peatland to open wetlands. Roads and highways traversing large peatlands complexes, especially in the Upper Peninsula, have blocked drainage, causing flooding, tree mortality, and conversion to open wetlands. Conversely, ditches and drains that lower water tables can result in rapid decomposition of peat and increased shrub and tree encroachment.

Monitoring and control efforts to detect and remove invasive species before they become widespread are critical to the long-term viability of poor conifer swamp. Particularly aggressive invasive species that may threaten the diversity and community structure include glossy buckthorn (*Rhamnus frangula*), narrow-leaved cat-tail (*Typha angustifolia*), hybrid cat-tail (*Typha xglauca*), reed canary grass (*Phalaris arundinacea*), and reed (*Phragmites australis*). At present, most invasive species appear to be restricted to the margins of the poor conifer swamps, where they occur in moats or ditches along roads and trails that border the community.

Variation

Subtle variations in overall species composition and physiognomy of poor conifer swamp occur across its range along north-south and east-west climatic gradients. Poor conifer swamps are common throughout the northern Lower Peninsula and the Upper Peninsula and are rare south of the climatic tension zone. In the southern part of the Lower Peninsula, vegetation composition is influenced by minerotrophy and a warmer climate. Tall shrubs, particularly smooth highbush blueberry (*Vaccinium corymbosum*), are more prevalent in southern systems.

Similar Natural Communities

Bog, muskeg, northern fen, patterned fen, poor fen, rich tamarack swamp, and rich conifer swamp.

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For a full list of references used to create this description, please refer to the natural community abstract for poor conifer swamp.

Rich Conifer Swamp

Global/State Rank: G4/S3

Overview

Rich conifer swamp is a groundwater-influenced, minerotrophic, forested wetland dominated by northern white-cedar (*Thuja occidentalis*) that occurs on organic soils (i.e., peat) primarily north of the climatic tension zone in the northern Lower and Upper Peninsulas. The community is also referred to as cedar swamp.

Landscape Context

Rich conifer swamp occurs in outwash channels, outwash plains, glacial lakeplains, and in depressions on coarse- to medium-textured ground moraines. It is common in outwash channels of drumlin fields and where groundwater seeps occur at the bases of moraines. Rich conifer swamp typically occurs in association with lakes and cold, groundwater-fed streams. It also occurs along the Great Lakes shoreline in old abandoned embayments and in swales between former beach ridges where it may be part of a wooded dune and swale complex.

Climatic conditions in the community are influenced by its northerly distribution, low topographic position, and thick layer of mosses, especially sphagnum (*Sphagnum* spp.), which insulate the organic soils. At night, cold air drains down from the surrounding uplands throughout the growing season, causing condensation to collect on plants. This constant source of nocturnal moisture helps sustain the community's abundant lichen and bryophyte flora. The cold air drainage may also cause nighttime temperatures to drop below freezing throughout the growing season. The insulating properties of sphagnum moss allow ice to remain within the upper layers of soil until mid-June or July, but in the fall, soils remain unfrozen until after snowfall, and deep penetration of frost may not occur until February. Thus, rich conifer swamp has a shorter, cooler, and more humid growing season than the surrounding uplands, while winters are milder and more even in temperature.

Soils

The soils are composed of saturated, coarse woody peat and may vary significantly in depth of organic matter. The organic soils are typically neutral to moderately alkaline but may be very strongly acid near the surface where sphagnum mosses dominate the ground layer. The structure and species composition of rich conifer swamp are strongly influenced by the constant flow of mineral-rich, cold groundwater through the organic soils.

Natural Processes

Seasonal water level fluctuations, beaver flooding, windthrow, and fire are all important forms of natural disturbance for rich conifer swamp. Although rich conifer swamp is primarily groundwater fed, seasonal water-level fluctuations are common with water levels highest in spring and lowest in late summer and fall. In response to seasonal water level fluctuations, the roots of northern white-cedar and tamarack form extensive mats that stand elevated above adjacent inundated muck-flats or carpets of moss, creating a varied microtopography. Beaver flooding can cause extensive mortality of northern white-cedar and other woody plants, significantly altering community structure and composition. Prolonged flooding can cause conversion to shallow pond, emergent marsh, northern wet meadow, northern fen, poor fen, or northern shrub thicket depending on the depth and duration of inundation, local topography, and groundwater chemistry.

Due to anaerobic conditions associated with a high water table and organic soils, trees growing in rich conifer swamps are shallowly rooted, making them susceptible to frequent small-scale windthrow. As a result, leaning, bent, or fallen trees are common, creating tip-up mounds, abandoned root pits, and coarse woody debris that contribute to the complex structure and microtopography of rich conifer swamp. Northern white-cedar is well adapted to windthrow because of its ability to reproduce both sexually, through seed, and asexually, by growing adventitious roots when its lateral branches are in contact with the ground (i.e., layering).

Fire may spread through the community during extensive periods of drought, killing many woody plants and in some instances, removing the upper layers of organic soil. Fire can also play a role in the community's establishment. Seedlings of northern white-cedar can establish directly on burned-over organic soils or within alder thickets that originate following catastrophic fire in poor conifer swamp. Catastrophic fire and windfall in northern Lower Michigan conifer swamps are estimated to have occurred at intervals of approximately 3,000 years.

Vegetation

The structure of rich conifer swamp is shaped by northern white-cedar, the dominant tree species. Northern white-cedar is a relatively short tree (20 m or 66 ft) and often forms a dense, low canopy, which can prevent other tree species from establishing. Because windthrow is very common, portions of the community often appear as a dense tangle of fallen, leaning, and misshapen northern white-cedar. The complex community structure is further enhanced by the root hummocks of northern white-cedar, which are often elevated above adjacent saturated or flooded organic soil.

In addition to northern white-cedar, other common trees species may include balsam fir (*Abies balsamea*), tamarack (*Larix laricina*), black spruce (*Picea mariana*), white spruce (*P. glauca*), hemlock (*Tsuga canadensis*), white pine (*Pinus strobus*), black ash (*Fraxinus nigra*), red maple (*Acer rubrum*), yellow birch (*Betula alleghaniensis*), paper birch (*Betula papyrifera*), American elm (*Ulmus americana*), quaking aspen (*Populus tremuloides*), and balsam poplar (*Populus balsamifera*).

Shrubs can be very common, especially within recent windfalls. Tall shrub species occurring in rich conifer swamp include tag alder (*Alnus rugosa*), winterberry (*Ilex verticillata*), mountain holly (*Nemopanthus mucronata*), red-osier dogwood (*Cornus stolonifera*), elderberry (*Sambucus canadensis*), red elderberry (*S. racemosa*), huckleberry (*Gaylussacia baccata*), autumn willow (*Salix serissima*), and Canadian yew (*Taxus canadensis*). Early accounts list Canadian yew as one of the most common understory species, but this plant has since been sharply reduced or extirpated from most cedar swamps as a result of herbivory by deer. Balsam fir also commonly occurs as part of the shrub layer, sometimes forming dense patches.

Low shrub species common to rich conifer swamp can include Labrador tea (*Ledum groenlandicum*), low sweet blueberry (*Vaccinium angustifolium*), Canada blueberry (*V. myrtilloides*), leatherleaf (*Chamaedaphne calyculata*), American fly honeysuckle (*Lonicera canadensis*), hairy honeysuckle (*L. hirsuta*), swamp fly honeysuckle (*L. oblongifolia*), wild black currant (*Ribes americanum*), swamp red current (*R. triste*), and swamp black current (*R. lacustre*). Common vine species in rich conifer swamp include poison ivy (*Toxicodendron radicans*) and red honeysuckle (*Lonicera dioica*).

The ground layer of rich conifer swamp can be especially diverse in sedges, ferns, orchids, forbs, liverworts, and mosses. Common sedges may include *Carex gynocrates*, *C. leptalea*, *C. disperma*, *C. trisperma*, *C. interior*, *C. eburnea*, and *C. vaginata*. Common fern species may

include maidenhair fern (*Adiantum pedatum*), lady fern (*Athyrium filix-femina*), rattlesnake fern (*Botrychium virginianum*), bulblet fern (*Cystopteris bulbifera*), spinulose woodfern (*Dryopteris carthusiana*), crested woodfern (*D. cristata*), glandular woodfern (*D. intermedia*), oak fern (*Gymnocarpium dryopteris*), sensitive fern (*Onoclea sensibilis*), cinnamon fern (*Osmunda cinnamomea*), marsh fern (*Thelypteris palustris*), northern beech fern (*Thelypteris phegopteris*), and New York fern (*T. noveboracensis*). Common orchids may include early coralroot (*Corallorhiza trifida*), small yellow lady's-slipper (*Cypripedium calceolus* var. *parviflorum*), showy lady's-slipper (*Cypripedium reginae*), tall white bog orchid (*Platanthera dilatata*), blunt-leaved orchid (*Platanthera obtusata*), tall northern bog orchid (*Platanthera hyperborea*), heart-leaved twayblade (*Listera cordata*), and broad-leaved twayblade (*L. convallarioides*). Additional common ground flora may include wild sarsaparilla (*Aralia nudicaulis*), Jack-in-the-pulpit (*Arisaema triphyllum*), marsh marigold (*Caltha palustris*), small enchanter's nightshade (*Circaea alpina*), goldthread (*Coptis trifolia*), bunchberry (*Cornus canadensis*), water horsetail (*Equisetum fluviatile*), fragrant bedstraw (*Galium triflorum*), creeping snowberry (*Gaultheria hispida*), wintergreen (*G. procumbens*), purple avens (*Geum rivale*), rattlesnake grass (*Glyceria canadensis*), fowl manna grass (*G. striata*), jewelweed (*Impatiens capensis*), wild blue flag (*Iris versicolor*), twinflower (*Linnaea borealis*), Canada mayflower (*Maianthemum canadense*), naked miterwort (*Mitella nuda*), one-flowered pyrola (*Moneses uniflora*), gay wings (*Polygala paucifolia*), pink pyrola (*Pyrola asarifolia*), round-leaved pyrola (*Pyrola rotundifolia*), dwarf raspberry (*Rubus pubescens*), mad-dog skullcap (*Scutellaria lateriflora*), twisted-stalk (*Streptopus amplexifolius*), and starflower (*Trientalis borealis*).

Mat-forming mosses can cover large portions of rich conifer swamp. Nearly the entire surface of nurse logs can be covered by callicladium moss (*Callicladium haldanianum*) and feather moss (*Pleurozium schreberi*). Common sphagnum mosses that can cover large portions of the forest floor in some rich conifer swamps include *Sphagnum centrale*, *S. squarrosum*, *S. girgensohnii*, *S. wulfinaum*, *S. warnstorffii*, and *S. centrale*.

Noteworthy Animals

Rich conifer swamps provide critical winter habitat for white-tailed deer (*Odocoileus virginianus*) and snowshoe hare (*Lepus americanus*). Beaver-induced flooding can result in widespread mortality of northern white-cedar and other species not adapted to prolonged flooding.

Rare Plants

Amerorchis rotundifolia (round-leaved orchis, state endangered)
Aster modestus (great northern aster, state threatened)
Calypso bulbosa (calypso, state threatened)
Carex heleonastes (Hudson Bay sedge, state endangered)
Cypripedium arietinum (ram's head lady's-slipper, state special concern)
Empetrum nigrum (black crowberry, state threatened)
Erigeron hyssopifolius (hyssop-leaved fleabane, state threatened)
Gymnocarpium robertianum (limestone oak fern, state threatened)
Lonicera involucreta (black twinberry, state threatened)
Mimulus glabratus var. *michiganensis* (Michigan monkey-flower, state endangered)
Parnassia palustris (marsh-grass-of-Parnassus, state threatened)
Pinguicula vulgaris (butterwort, state special concern)
Ranunculus lapponicus (Lapland buttercup, state threatened)
Senecio indecorus (rayless mountain ragwort, state threatened)
Solidago houghtonii (Houghton's goldenrod, federal/state threatened)
Stellaria crassifolia (fleshy stitchwort, state endangered)
Vaccinium vitis-idaea (mountain-cranberry, state endangered)

Rare Animals

Accipiter gentilis (northern goshawk, state special concern)
Alces americanus (moose, state special concern)
Appalachina sayanus (spike-lip crater, state special concern)
Asio otus (long-eared owl, state special concern)
Buteo lineatus (red-shouldered hawk, state threatened)
Canis lupus (gray wolf, federal endangered and state threatened)
Dendragapus canadensis (spruce grouse, state special concern)
Felis concolor (cougar, state endangered)
Glyptemys insculpta (wood turtle, state special concern)
Hendersonia occulta (cherrystone drop, state threatened)
Lynx canadensis (lynx, federal threatened and state endangered)
Pandion haliaetus (osprey, state special concern)
Picoides arcticus (black-backed woodpecker, state special concern)
Sistrurus c. catenatus (eastern massasauga, federal candidate species and state special concern)
Somatochlora hineana (Hine's emerald, federal/state endangered)

Biodiversity Management Considerations

Rich conifer swamp is a self-maintaining, stable community that relies on gap-phase dynamics to regenerate long-lived, shade-tolerant, northern white-cedar. A major threat to natural regeneration of cedar in northern rich conifer swamps is high density of deer, which rely on cedar as a main winter-staple. Logging rich conifer swamps can facilitate its conversion to hardwood-conifer swamps, hardwood swamps, aspen, and alder thickets. Long-term conservation of rich conifer swamps will require reducing deer densities across the landscape and allowing natural disturbances such as windthrow to create the complex structure that creates habitat for late-successional species.

Invasive species that threaten the diversity and community structure of rich conifer swamp include glossy buckthorn (*Rhamnus frangula*), purple loosestrife (*Lythrum salicaria*), narrow-leaved cat-tail (*Typha angustifolia*), hybrid cat-tail (*Typha xglauca*), reed (*Phragmites australis*), reed canary grass (*Phalaris arundinacea*), and European marsh thistle (*Cirsium palustre*). Regular monitoring for these and other invasive species followed by prompt and sustained control efforts will help protect the ecological integrity of rich conifer swamp and adjacent natural communities.

Variation

Rich conifer swamp occurs throughout the upper Midwest and northeast United States and adjacent Canadian provinces. South of the climatic tension zone in southern Lower Michigan, tamarack typically becomes the dominant conifer in minerotrophic wetlands. Minerotrophic wetlands dominated by tamarack in southern Lower Michigan are classified as rich tamarack swamp.

Similar Natural Communities

Rich tamarack swamp, hardwood-conifer swamp, poor conifer swamp, northern hardwood swamp, boreal forest, and wooded dune and swale complex.

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For a full list of references used to create this description, please refer to the natural community abstract for rich conifer swamp.

Rich Tamarack Swamp

Global/State Rank: G4/S3

Overview

Rich tamarack swamp is a groundwater-influenced, minerotrophic, forested wetland dominated by tamarack (*Larix laricina*) that occurs on deep organic soils predominantly south of the climatic tension zone in southern Lower Michigan. This natural community type was known as relict conifer swamp in previous versions of the natural community classification.

Landscape Context

Rich tamarack swamp occurs in outwash channels, outwash plains, and kettle depressions throughout southern Lower Michigan. The community is often found where groundwater seeps occur at the bases of moraines. Rich tamarack swamps typically occur in association with headwater streams and adjacent to inland lakes. In large wetland complexes, rich tamarack swamp is typically associated with southern shrub-carr, prairie fen, southern wet meadow, and emergent marsh.

Soils

The organic soils underlying rich tamarack swamp are typically comprised of deep (> 2.5 m) peat containing large amounts of woody debris and occasionally layers of sedge-dominated peat. The soil profile often contains or is underlain by marl, a calcium carbonate precipitate that accumulates as sediment in shallow lake bottoms. Because glacial till in southern Michigan is typically high in calcium and magnesium, the groundwater discharge into rich tamarack swamp has high levels of alkalinity and dissolved calcium and magnesium carbonates.

Natural Processes

Windthrow, insect outbreak, beaver flooding, and fire are all important forms of natural disturbance for rich tamarack swamp. Trees growing in the anaerobic conditions associated with a high water table and peat soils tend to be shallowly rooted and are thus, especially prone to windthrow. The light gaps created by windthrow help to regenerate tamarack and maintain the community's dense shrub layer. In addition, the coarse woody debris and pit and mound microtopography that results from windthrow add to the community's complex structure and floristic diversity.

Periodic outbreaks of larch sawfly (*Pristiphora erichsonii*) and eastern larch beetle (*Dendroctonus simplex*), both native insect species, and the introduced larch casebearer (*Coleophora laricella*) can cause significant mortality of tamarack. The defoliation associated with an insect outbreak results in increased light reaching the understory, which may promote tamarack regeneration and high shrub-layer density. However, these defoliation events also promote the growth of red maple, which subsequently reduces the amount of light available to the understory and ground layers and results in lower species richness.

Due to the strong influence of groundwater, water levels in rich tamarack swamps tend to fluctuate less than in many other wetland types. However, the community is subject to seasonal water fluctuations and long-term flooding associated with beaver dams or blocked road culverts. Although the roots of tamarack form elevated hummocks that allow it to withstand small-scale water level fluctuations, prolonged flood events result in tamarack mortality and the conversion of rich tamarack swamp to emergent marsh, southern wet meadow, or southern shrub-carr.

While fire is not a frequent form of direct disturbance in rich tamarack swamps, its influence on the surrounding landscape is very important to the successional dynamics of this community. With the widespread absence of fire in southern Michigan, tamarack, a common tree within prairie fens, has completely colonized many sites that were previously occupied by prairie fen, thus forming many of the rich tamarack swamps we see today. Additionally, fire suppression in the surrounding landscape has facilitated the increase and dominance of red maple within upland forests. As a result, red maple is now more likely to colonize rich tamarack swamps and replace tamarack, especially following disturbances such as insect outbreaks and windthrows.

Vegetation

The structure of this community is largely shaped by tamarack, the dominant tree species. The roots of tamarack often form extensive mats that stand elevated above adjacent pools of standing water and provide a substrate for a diverse wetland ground flora that differs from that of the inundated mudflats between root hummocks. The varied microtopography fosters biocomplexity and high species richness. Tamarack windthrows and tip-up mounds also add to the heterogeneous structure of the ground and shrub layers. Because of the open branching and spire-like shape of tamarack, the shrub layer of rich tamarack swamp receives a high level of light and is typically both very dense and diverse. The shrub layer may contain as many as 28 species, with multiple species intertwined and over-topping one another so that total shrub-layer cover may reach 90 to 130%.

In addition to tamarack, other common tree species include black ash (*Fraxinus nigra*), yellow birch (*Betula alleghaniensis*), American elm (*Ulmus americana*), red maple (*Acer rubrum*), swamp white oak (*Quercus bicolor*), quaking aspen (*Populus tremuloides*), red cedar (*Juniperus virginiana*), and in some locations white pine (*Pinus strobus*) and northern white-cedar (*Thuja occidentalis*). Common tall shrub species include poison sumac (*Toxicodendron vernix*), winterberry (*Ilex verticillata*), smooth highbush blueberry (*Vaccinium corymbosum*), gray dogwood (*Cornus foemina*), silky dogwood (*C. amomum*), swamp rose (*Rosa palustris*), American hazelnut (*Corylus americana*), nannyberry (*Viburnum lentago*), juneberry (*Amelanchier arborea*), black chokeberry (*Aronia prunifolia*), and pussy willow (*Salix discolor*). Low shrub species common to rich tamarack swamp include swamp gooseberry (*Ribes hirtellum*), wild red raspberry (*Rubus strigosus*), bog birch (*Betula pumila*), sage willow (*Salix candida*), swamp fly honeysuckle (*Lonicera oblongifolia*), alder-leaved buckthorn (*Rhamnus alnifolia*), common juniper (*Juniperus communis*), shrubby cinquefoil (*Potentilla fruticosa*), and bog willow (*Salix pedicellaris*). Common woody vines include poison ivy (*Toxicodendron radicans*), Virginia creeper (*Parthenocissus quinquefolia*), and riverbank grape (*Vitis riparia*).

Because of the high frequency of canopy disturbance and open structure of tamarack, the ground flora is composed of a heterogeneous mixture of shade-tolerant and intolerant wetland plants. In addition, the stark difference in moisture levels between the elevated root hummocks and saturated muck flats also significantly increases the diversity of wetland species found in the ground flora. Common ground flora in rich tamarack swamp include the following species: smooth swamp aster (*Aster firmus*), swamp aster (*A. puniceus*), eastern lined aster (*A. lanceolatus*), nodding bur-marigold (*Bidens cernuus*), tall swamp-marigold (*B. coronatus*), false nettle (*Boehmeria cylindrica*), bluejoint grass (*Calamagrostis canadensis*), marsh marigold (*Caltha palustris*), marsh bellflower (*Campanula aparinoides*), Pennsylvania bitter cress (*Cardamine pensylvanica*), sedges (*Carex comosa*, *C. hystericina*, *C. lacustris*, *C. leptalea*, and *C. stricta*), water hemlock (*Cicuta bulbifera*), spinulose woodfern (*Dryopteris carthusiana*), water horsetail (*Equisetum fluviatile*), rough bedstraw (*Galium asprellum*), bog bedstraw (*G. labradoricum*), stiff bedstraw (*G. tinctorium*), fowl manna grass (*Glyceria striata*), jewelweed (*Impatiens capensis*), cut grass (*Leersia oryzoides*), small duckweed (*Lemna minor*), northern

bugle weed (*Lycopus uniflorus*), tufted loosestrife (*Lysimachia thyrsiflora*), Canada mayflower (*Maianthemum canadense*), sensitive fern (*Onoclea sensibilis*), royal fern (*Osmunda regalis*), clearweed (*Pilea pumila*), dwarf raspberry (*Rubus pubescens*), common arrowhead (*Sagittaria latifolia*), mad-dog skullcap (*Scutellaria lateriflora*), golden ragwort (*Senecio aureus*), swamp goldenrod (*Solidago patula*), rough goldenrod (*S. rugosa*), false mayflower (*Smilacina trifolia*), skunk cabbage (*Symplocarpus foetidus*), marsh fern (*Thelypteris palustris*), starflower (*Trientalis borealis*), and violets (*Viola* spp.).

While mosses, especially brown mosses (*Amblystegiaceae*), are prevalent throughout the ground layer, sphagnum mosses (*Sphagnum* spp.) are usually only locally distributed.

Noteworthy Animals

Beaver-induced flooding can result in widespread mortality of tamarack and other species not adapted to inundated conditions. Periodic outbreaks of the larch sawfly (*Pristiphora erichsonii*) and larch casebearer (*Coleophora laricella*) result in significant reductions in tamarack-cover, and repeated defoliation events can cause tamarack-mortality. Fall migrating songbirds and other resident birds and small mammals feed on the abundance of fruit produced by the dense shrub layer of rich tamarack swamp.

Rare Plants

Berula erecta (water parsnip, state threatened)
Cacalia plantaginea (prairie Indian-plantain, state special concern)
Calamagrostis stricta (narrow-leaved reedgrass, state threatened)
Cypripedium candidum (white lady's-slipper, state threatened)
Drosera anglica (English sundew, state special concern)
Filipendula rubra (queen-of-the-prairie, state threatened)
Muhlenbergia richardsonis (mat muhly, state threatened)
Phlox maculata (sweet william phlox, state threatened)
Poa paludigena (bog bluegrass, state threatened)
Polemonium reptans (Jacob's ladder, state threatened)
Sporobolus heterolepis (prairie dropseed, state special concern)
Valeriana edulis var. *ciliata* (edible valerian, state threatened)

Rare Animals

Clemmys guttata (spotted turtle, state special concern)
Emydoidea blandingii (Blanding's turtle, state special concern)
Oecanthus laricis (tamarack tree cricket, state special concern)
Neonympha m. mitchellii (Mitchell's satyr butterfly, federal/state endangered)
Sistrurus c. catenatus (eastern massasauga, federal candidate species and state special concern)

Biodiversity Management Considerations

The presence of conifer-dominated wetlands in southern Michigan contributes significantly to the region's overall biodiversity. Protecting the hydrology of rich tamarack swamp is critical for its continued existence and may include avoiding surface water inputs to the community from drainage ditches and agricultural fields, clearing blocked road culverts, which can cause prolonged flooding, and maintaining native vegetation types in the uplands surrounding the community.

Invasion by red maple can cause rich tamarack swamp to shift toward hardwood domination, resulting in a significant decrease in shrub-layer cover and loss of shade-intolerant species such as tamarack. Reducing red maple cover in rich tamarack swamps by girdling in conjunction with

trunk-application of wetland-approved herbicide may be effective in limiting its dominance. Ideally, this type of management would accompany the use of prescribed fire and removal of red maple in the upland forests adjacent to the swamp as well as hydrologic restoration where necessary. Significantly reducing red maple cover within the swamp and adjacent upland will help ensure that characteristic natural disturbance events, such as windthrow and insect outbreaks, result in tamarack regeneration rather than further proliferation of red maple.

Invasive species that can reduce species diversity and alter community structure include glossy buckthorn (*Rhamnus frangula*), multiflora rose (*Rosa multiflora*), purple loosestrife (*Lythrum salicaria*), narrow-leaved cat-tail (*Typha angustifolia*), hybrid cat-tail (*Typha xglauca*), reed (*Phragmites australis*), reed canary grass (*Phalaris arundinacea*), and European marsh thistle (*Cirsium palustre*), the latter species mostly restricted to northern Michigan at present. Glossy buckthorn is probably the greatest threat to rich tamarack swamps as it is capable of completely dominating the shrub and ground layers. Removing glossy buckthorn can be accomplished with cutting, accompanied by herbicide application and by using spot-burning to eliminate seedlings. Regular monitoring for invasive species followed by prompt and sustained control efforts will help protect the ecological integrity of rich tamarack swamp and other adjacent natural communities.

Variation

Throughout northern Michigan and near the tension zone in mid-Michigan, northern white-cedar (*Thuja occidentalis*) replaces tamarack as the dominant tree species in groundwater-influenced, forested wetlands. Precipitation-fed (ombrotrophic) acidic, tamarack and black spruce swamps also occur in southern Michigan and are classified as poor conifer swamp. Many large wetland complexes contain zones of both minerotrophic tamarack swamp (e.g., rich tamarack swamp) near the upland edge where groundwater seeps occur, as well as ombrotrophic tamarack swamp (e.g., poor conifer swamp) near the center of the complex. In the ombrotrophic zone, deep peat separates the vegetation from the influence of groundwater and sphagnum mosses acidify the surface peat.

Similar Natural Communities

Rich conifer swamp, hardwood-conifer swamp, southern hardwood swamp, northern hardwood swamp, poor conifer swamp, prairie fen, southern shrub-carr, and southern wet meadow.

Relevant Literature

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For a full list of references used to create this description, please refer to the natural community abstract for rich tamarack swamp.

Hardwood-Conifer Swamp

Global/State Rank: G4/S3

Overview

Hardwood-conifer swamp is a minerotrophic forested wetland dominated by a mixture of lowland hardwoods and conifers, occurring on organic (i.e., peat) and poorly drained mineral soils throughout Michigan. The community occurs on a variety of landforms, often associated with headwater streams and areas of groundwater discharge. Species composition and dominance patterns can vary regionally. Windthrow and fluctuating water levels are the primary natural disturbances that structure hardwood-conifer swamp.

Landscape Context

Hardwood-conifer swamp is typically associated with headwater streams or shallow kettle depressions in poorly drained outwash channels or in depressions on outwash plains, medium- to coarse-textured end moraines, and glacial lakeplains. Shallow kettle depressions and the margins of large forested and non-forested peatlands may also support hardwood-conifer swamp, but the community is absent from areas where significant peat accumulation isolates the rooting zone from contact with mineral-rich groundwater. Occurrences of hardwood-conifer swamp are often narrow (typically <500 m wide), following slope contours.

Soils

Substrate conditions are heterogeneous, and are often highly variable within a single stand. The most common condition is a thin layer of organic soil over a poorly drained mineral substrate. Organic soils are typically saturated, highly decomposed, sapric peat (i.e., muck) and frequently contain pieces of coarse wood throughout their soil profiles. Areas of deep (>1 m) organic deposition are common, especially in seeps. Substrate pH is also highly variable. Saturated mucks are typically of neutral pH, but may be acidic near the surface, especially where associated with sphagnum mosses or where coniferous needle mats accumulate. Mineral soils are often acidic. Vegetation (living and dead), depth to the water table, and groundwater movement all influence substrate alkalinity.

Natural Processes

The primary natural processes structuring hardwood-conifer swamp are windthrow and dynamics of surface water and groundwater. Patchy windthrow creates small-scale canopy gaps and complex microtopography, which influence ground layer diversity. Accumulation of ice and snow in tree crowns increases the likelihood of windthrow or trunk snap, particularly for trees weakened by pests or fungal pathogens. The creation of canopy gaps and associated microtopographic heterogeneity has important consequences for the establishment and recruitment of canopy trees. Seedlings of several characteristic hardwood-conifer swamp canopy tree species (e.g., yellow birch, white pine, northern white-cedar, and hemlock) preferentially germinate and establish on hummocks and/or decaying logs versus muck or litter-covered hollows. In comparison to hollows, hummocks and decaying logs have high moss cover, high moisture content, coarse substrate texture, and stable hydrology, characteristics that favor the germination and establishment of small seeds with low nutrient reserves.

Significant hydrological processes impacting hardwood-conifer swamp include groundwater seepage, water table fluctuation, seasonal inundation, and flooding events (often associated with beaver activity). Plant species composition is influenced by groundwater seepage rich in calcium

and magnesium carbonates. Water table fluctuations interact with canopy gap size, such that mid- and large-sized gaps may flood quickly during rain events, presumably due to the lack of canopy to intercept precipitation, in addition to the lack of transpiration by large trees. These wet gaps create microheterogeneity that results in increased diversity of vascular plant species, including many species otherwise characteristic of open wetland types.

The relative contribution of fire to hardwood-conifer swamp structure and succession is unknown, but fire does create suitable conditions for the establishment of new cohorts of several canopy dominants. Return intervals for destructive crown fires in conifer-dominated swamps have been estimated at up to 3,000 years in north-central Lower Michigan. However, less severe surface fires may occur with greater frequency.

Vegetation

Species composition within hardwood-conifer swamps exhibits considerable variation across the state. Canopy closure varies, depending on substrate characteristics and the disturbance history of each individual site. In southern Lower Michigan, canopy dominance is often by red maple (*Acer rubrum*) and black ash (*Fraxinus nigra*), with yellow birch (*Betula alleghaniensis*) and white pine (*Pinus strobus*) common canopy associates. Additional canopy species may include American elm (*Ulmus americana*), basswood (*Tilia americana*), northern white-cedar (*Thuja occidentalis*), hemlock (*Tsuga canadensis*), tamarack (*Larix laricina*), and, locally, tulip tree (*Liriodendron tulipifera*). In northern Michigan, canopy dominance is often by hemlock, and associates may include yellow birch, red maple, black ash, basswood, American elm, balsam poplar (*Populus balsamifera*), white pine, northern white-cedar, tamarack, balsam fir (*Abies balsamea*), white spruce (*Picea glauca*), and black spruce (*P. mariana*). Geographic variants occurring primarily north of the tension zone include stands that are dominated almost exclusively by hemlock and in the western Upper Peninsula by hemlock and yellow birch.

Small trees and tall shrubs form an open to closed subcanopy, depending on canopy closure. This layer is characterized by saplings of canopy species, in addition to mountain maple (*Acer spicatum*), tag alder (*Alnus rugosa*), paper birch (*Betula papyrifera*), musclewood (*Carpinus caroliniana*), red-osier dogwood (*Cornus stolonifera*), gray dogwood (*C. foemina*), winterberry (*Ilex verticillata*), poison sumac (*Toxicodendron vernix*), and spicebush (*Lindera benzoin*). Characteristic low shrubs include American fly honeysuckle (*Lonicera canadensis*) and alder-leaved buckthorn (*Rhamnus alnifolia*). Historically, Canadian yew (*Taxus canadensis*) was a prevalent shrub in hardwood-conifer swamp, but has since been reduced or locally extirpated from most sites by heavy deer herbivory.

The ground layer ranges from sparse under the shade of conifers to dense in light gaps and openings, and is characterized by the development of moss- and litter-covered hummocks and saturated, often inundated hollows on exposed muck soils. Characteristic species of hummocks and decomposing wood include wild sarsaparilla (*Aralia nudicaulis*), small enchanter's nightshade (*Circaea alpina*), bluebead lily (*Clintonia borealis*), goldthread (*Coptis trifolia*), bunchberry (*Cornus canadensis*), woodfern (*Dryopteris* spp.), oak fern (*Gymnocarpium dryopteris*), Canada mayflower (*Maianthemum canadense*), partridge berry (*Mitchella repens*), naked miterwort (*Mitella nuda*), dwarf raspberry (*Rubus pubescens*), and starflower (*Trientalis borealis*). Typical species of hollows and open, mucky flats include jack-in-the-pulpit (*Arisaema triphyllum*), beggar-ticks (*Bidens* spp.), sedges (including *Carex intumescens*, *C. crinita*, *C. disperma*, *C. gracillima*, *C. hystericina*, *C. lacustris*, *C. stricta*, *C. bromoides*, and others), fowl manna grass (*Glyceria striata*), jewelweed (*Impatiens capensis*), northern bugle weed (*Lycopus uniflorus*), sensitive fern (*Onoclea sensibilis*), cinnamon fern (*Osmunda cinnamomea*), royal fern

(*O. regalis*), golden ragwort (*Senecio aureus*), rough goldenrod (*Solidago rugosa*), and skunk cabbage (*Symplocarpus foetidus*).

Vines are often conspicuous in hardwood-conifer swamps, particularly in canopy gaps and along streams. Characteristic species include hog-peanut (*Amphicarpaea bracteata*), groundnut (*Apios americana*), virgin's bower (*Clematis virginiana*), wild yam (*Dioscorea villosa*), honeysuckles (primarily *Lonicera dioica*), Virginia creeper (*Parthenocissus quinquefolia*), poison ivy (*Toxicodendron radicans*), and riverbank grape (*Vitis riparia*).

Noteworthy Animals

Through flooding and herbivory, beaver (*Castor canadensis*) can cause tree mortality and the conversion to open wetlands such as shallow ponds, emergent marsh, wet meadows, shrub swamps, or fens. Insect outbreaks and plant parasites can set back or kill conifers, altering community composition and structure. The larch sawfly (*Pristiphora erichsonii*), larch casebearer (*Coleophora laricella*), and spruce budworm (*Choristoneura fumiferana*) can repeatedly defoliate and kill tamarack. Spruce budworm also defoliates both black spruce and balsam fir but tends to be more detrimental to the latter. The plant parasite dwarf mistletoe (*Arceuthobium pusillum*) can increase the mortality of black spruce.

Rare Plants

Berula erecta (cut-leaved water-parsnip, state threatened)

Carex seorsa (sedge, state threatened)

Dentaria maxima (large toothwort, state threatened)

Hydrastis canadensis (goldenseal, state threatened)

Lonicera involucrata (black twinberry, state threatened)

Mimulus glabratus var. *michiganensis* (Michigan monkey-flower, federal/state endangered)

Poa paludigena (bog bluegrass, state threatened)

Trillium undulatum (painted trillium, state endangered)

Rare Animals

Accipiter gentilis (northern goshawk, state special concern)

Alces americanus (moose, state special concern)

Appalachina sayanus (spike-lip crater, state special concern)

Ardea herodias (great blue heron, protected by the Migratory Bird Treaty Act of 1918)

Asio otus (long-eared owl, state threatened)

Buteo lineatus (red-shouldered hawk, state threatened)

Canis lupus (gray wolf, federal endangered and state threatened)

Emydoidea blandingii (Blanding's turtle, state special concern)

Glyptemys insculpta (wood turtle, state special concern)

Gomphus quadricolor (rapids clubtail, state special concern)

Haliaeetus leucocephalus (bald eagle, state special concern)

Incisalia henrici (Henry's elfin, state threatened)

Pachypolia atricornis (three-horned moth, state special concern)

Pandion haliaetus (osprey, state special concern)

Papaipema speciosissima (regal fern borer, state special concern)

Sistrurus c. catenatus (eastern massasauga, federal candidate species and state special concern)

Tachopteryx thoreyi (grey petaltail, state threatened)

Terrapene c. carolina (eastern box turtle, state special concern)

Williamsonia fletcheri (ebony boghaunter, state special concern)

Biodiversity Management Considerations

Conservation and management of hardwood-conifer swamp should focus on the following key areas: maintenance of the coarse woody debris resource; protection of mature seed-bearing trees; maintenance of canopy gap structure; protection of groundwater and surface water hydrology; reduction of deer browse pressure; and control and monitoring of invasive species, including plants, animals, and pathogens.

Regeneration of hardwood-conifer swamp canopy trees, particularly of conifers, relies on the presence of suitable sites for germination and establishment within the stand. Management should focus on protecting decaying logs and hummocks that are favored germination sites for yellow birch, white pine, northern white-cedar, and hemlock. Maintaining mature, senescent, and dead canopy trees within hardwood-conifer swamp stands ensures a continuing source of the large-diameter coarse woody debris important for seedling germination and survival. Removal of coarse woody debris or senesced trees from hardwood-conifer swamps should be avoided or minimized to ensure the continued viability of the system.

Maintaining mature, seed-bearing conifer trees is important for ensuring the continued presence of seed sources within the wetland. Removal of mature conifers from hardwood-conifer swamps should be carefully considered to avoid converting the affected stands to hardwood dominance. Expansion of red maple in some stands, often following logging or hydrologic disturbance, limits conifer seedling establishment and recruitment by reducing light availability at the ground level.

Protection of groundwater and surface water hydrology is critical to maintaining the integrity of the hardwood-conifer swamp community. Hydrologic disturbances, including road construction and ditching, cause peat subsidence and decomposition and alter water tables by draining water or blocking its flow.

High deer density has led to significant browse pressure on conifer seedlings and saplings and resulted in poor regeneration in much of the state. In addition, deer browse reduces frequency and cover of understory shrubs and herbs, altering structure of all strata and producing a cascade of effects extending to pollinators of affected plant species. Reduction of deer densities at the landscape-scale will promote recovery of tree seedling, shrub, and herb populations.

Invasive plant species that can reduce diversity and alter community structure of hardwood-conifer swamps include reed canary grass (*Phalaris arundinacea*), reed (*Phragmites australis*), purple loosestrife (*Lythrum salicaria*), autumn olive (*Elaeagnus umbellata*), and glossy buckthorn (*Rhamnus frangula*). Monitoring and control efforts to detect and remove these and other invasive species are important for protecting affected and surrounding natural communities. Pests of potential significant impact include the hemlock woolly adelgid (*Adelges tsugae*), which has the potential to cause significant hemlock mortality if it spreads throughout Michigan, and the emerald ash borer (*Agrilus planipennis*), which has already decimated ash populations in southeastern Lower Michigan.

Variation

There are several variants that share similar vegetative composition but exhibit different dominance patterns. In southern Lower Michigan, hardwoods, typically red maple, black ash, and yellow birch, dominate some stands, with a significant component of white pine and northern white-cedar. North of the tension zone, hemlock dominates some stands, sometimes to the near exclusion of other tree species. In the western Upper Peninsula, hemlock shares dominance with yellow birch in some stands. Elsewhere in northern Michigan, lowland hardwoods and boreal conifers exhibit mixed dominance patterns that require further study.

Similar Natural Communities

Rich conifer swamp, rich tamarack swamp, floodplain forest, northern hardwood swamp, southern hardwood swamp, and mesic northern forest.

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For a full list of references used to create this description, please refer to the natural community abstract for hardwood-conifer swamp.

Northern Hardwood Swamp

Global/State Rank: G4/S3?

Overview

Northern hardwood swamp is a seasonally inundated, deciduous swamp forest community dominated by black ash (*Fraxinus nigra*) that occurs on neutral to slightly acidic, hydric mineral soils and shallow muck over mineral soils. Located north of the climatic tension zone, northern hardwood swamp is found primarily in depressions on level to hummocky glacial lakeplains, fine- and medium-textured glacial tills, and broad flat outwash plains. Fundamental disturbance factors affecting northern hardwood swamp development include seasonal flooding and windthrow.

Landscape Context

Northern hardwood swamps can be found in diverse landscape settings, including abandoned lakebeds, level to hummocky glacial lakeplains, shallow basins, groundwater seeps, low, level terrain near rivers, lakes, or wetlands, and small depressions around edges of peatlands. The majority of circa 1800 black ash swamps were located on flat lacustrine plains, fine- and medium-textured glacial tills, or broad flat outwash plains. Northern hardwood swamps occur on poorly drained soils and in areas that receive seasonal flooding or have high water tables. Perched saturated pockets and pools of standing water are common features of northern hardwood swamp, especially during spring. Because they occupy depressions, these ecosystems are colder than the immediately surrounding landscape.

Soils

Soils are poorly to very poorly drained and often consist of a shallow layer of muck (i.e., sapric peat) overlaying mineral soil. The texture of mineral soils is most commonly fine sandy clay loam to fine loam and an underlying impermeable clay lens is often present.

Natural Processes

Seasonal flooding is the primary disturbance in northern hardwood swamps. Standing water, usually a result of groundwater seepages, can reach over 30 cm (12 in) in depth, and is usually present in spring and drained by late summer. Water often pools due to an impermeable clay layer in the soil profile. Overstory species associated with flooding have several adaptations to soil saturation such as hypertrophied lenticels (oversized pores on woody stems that foster gas exchange between plants and the atmosphere), rapid stomatal closure, adventitious roots, and reproductive plasticity. Flooding extent has even been found to dictate the mode of regeneration for black ash. For example, heavy flooding events usually result in vegetative reproduction by stump sprouting, whereas less prolonged flooding fosters sexual reproduction.

Differences in species composition, in particular the distribution of different species of ash, are dependent upon variation in timing, extent, and duration of high water. The relationship between variations in flooding and species composition is demonstrated by the differences between black ash-dominated swamps, and river floodplains where green ash (*Fraxinus pennsylvanica*) is a more common dominant species. Green ash requires moving, oxygen-rich water characteristic of river floodplains, whereas black ash has adapted to the usually stagnant water with reduced oxygen content associated with swamp depressions. Green ash on river floodplains withstands routine flooding throughout the growing season. Black ash is very tolerant of low oxygen levels found in stagnant swamps, but is intolerant of flooding well into the growing season. Massive

dieback of understory and sometimes overstory trees results from extended periods of high water in northern hardwood swamps. An adaptation to this common occurrence is the long dormancy period (up to eight years) of black ash seeds. In northern hardwood swamps, drier periods that allow for exposure of saturated organic soils are essential for regeneration of swamp vegetation. However, because of the high water-retaining capacity of sapric peat, soil moisture within northern hardwood swamp is typically maintained throughout the growing season, unlike the mineral soils of many floodplains, which can experience summer droughts. While xeric stress is harmful to shallow rooting black ash seedlings, green ash commonly withstands periods of low soil moisture on river floodplains. Black ash–dominated northern hardwood swamp communities are therefore restricted to depressions, or low, level terrain near rivers, lakes, or wetlands that experience seasonal flooding but not the more pronounced levels of soil desiccation found in floodplain systems.

Historically, catastrophic disturbances in northern hardwood swamp other than flooding were most likely infrequent. Large-scale windthrow and fire in northern hardwood swamps of Minnesota had a rotation of 370 and 1000 years, respectively. However, small windthrow events are common in these systems due to shallow rooting within muck soils. The uprooting of trees creates pit and mound microtopography that results in fine-scale gradients of soil moisture and soil chemistry. Microtopography is an important driver of vegetation patterns within swamp systems since it provides a diversity of microsites for plant establishment. As floodwater drains, both the residual mucky pools and exposed mounds left by uprooted trees provide unique substrates for a variety of northern hardwood swamp plants. Coarse woody debris, which typically lies above the zone of flooding, remains a continued source of saturated substrate for seed germination and seedling establishment through drier periods.

A common agent in hydrologic change in northern hardwood swamps is beaver. Through dam-building activities, beaver can initiate substantial hydrologic change, either causing prolonged flooding or lowering of the water table depending on the location of the swamp in relation to the dam. Behind a beaver dam the water table is higher, while below it drier conditions are generated. In addition to altering hydrology, beaver can generate canopy gaps within these systems by cutting down trees. Through flooding and herbivory, beaver can cause tree mortality and the conversion of northern hardwood swamp to open wetlands such as northern shrub thicket or northern wet meadow.

Vegetation

Black ash (*Fraxinus nigra*) is the overwhelming canopy dominant of northern hardwood swamp communities. Canopy associates of black ash include red maple (*Acer rubrum*), silver maple (*A. saccharinum*), American elm (*Ulmus americana*), yellow birch (*Betula alleghaniensis*), basswood (*Tilia americana*), balsam fir (*Abies balsamea*), northern white-cedar (*Thuja occidentalis*), and green ash (*Fraxinus pennsylvanica*). However, these species are all found in greater density in other communities. The shrub layer can consist of saplings of overstory species along with winterberry (*Ilex verticillata*) and tag alder (*Alnus rugosa*). Northern hardwood swamps are characterized by a diverse ground flora that is patchy both seasonally and spatially depending on timing, location, and duration of flooding. Sites are often saturated to inundated in spring and following heavy rains, resulting in numerous sparsely vegetated to bare areas in the understory and ground layers. During the late growing season, when seasonal waters draw down, the herbaceous layer is typically dense.

Common herbaceous plants include northern bugleweed (*Lycopus uniflorus*), mad-dog skullcap (*Scutellaria lateriflora*), wood anemone (*Anemone quinquefolia*), jack-in-the-pulpit (*Arisaema triphyllum*), false nettle (*Boehmeria cylindrica*), marsh marigold (*Caltha palustris*), Pennsylvania

bitter cress (*Cardamine pensylvanica*), fringed sedge (*Carex crinita*), great bladder sedge (*C. intumescens*), small enchanter's nightshade (*Circaea alpina*), goldthread (*Coptis trifolia*), fragrant bedstraw (*Galium triflorum*), fowl manna grass (*Glyceria striata*), jewelweed (*Impatiens capensis*), wild iris (*Iris versicolor*), wood nettle (*Laportea canadensis*), Canada mayflower (*Maianthemum canadense*), wild mint (*Mentha arvensis*), partridge berry (*Mitchella repens*), naked miterwort (*Mitella nuda*), Virginia creeper (*Parthenocissus quinquefolia*), clearweed (*Pilea pumila*), elliptic shinleaf (*Pyrola elliptica*), dwarf raspberry (*Rubus pubescens*), water parsnip (*Sium suave*), skunk cabbage (*Symplocarpus foetidus*), and wild violets (*Viola* spp.). Common ferns include sensitive fern (*Onoclea sensibilis*), cinnamon fern (*Osmunda cinnamomea*), royal fern (*O. regalis*), ostrich fern (*Matteuccia struthiopteris*), and oak fern (*Gymnocarpium dryopteris*). In addition, horsetails (*Equisetum* spp.) are also prevalent in northern hardwood swamps.

Noteworthy Animals

Black ash seeds are an important food source for game birds, songbirds, and small mammals, and the leaves provide browse for white-tailed deer (*Odocoileus virginianus*) and moose (*Alces americanus*, state special concern). Beaver (*Castor canadensis*) can cause prolonged flooding, which results in widespread mortality of black ash and other species not adapted to such conditions.

Rare Plants

Carex assiniboinensis (Assiniboia sedge, state threatened)
Gentiana linearis (narrow-leaved gentian, state threatened)
Glyceria melicaria (slender manna grass, state threatened)
Poa paludigena (bog bluegrass, state threatened)

Rare Animals

Accipiter gentiles (northern goshawk, state special concern)
Alces americanus (moose, state special concern)
Appalachiana sayanus (spike-lip crater, state special concern)
Ardea herodias (great blue heron, protected by the Migratory Bird Treaty Act of 1918)
Canis lupus (gray wolf, federal endangered and state threatened)
Emydoidea blandingii (Blanding's turtle, state special concern)
Felis concolor (cougar, state endangered)
Haliaeetus leucocephalus (bald eagle, state special concern)
Pachypolia atricornis (three-horned moth, state special concern)
Pandion haliaetus (osprey, state special concern)
Sistrurus c. catenatus (eastern massasauga, federal candidate species and state special concern)
Terrapene c. carolina (eastern box turtle, state special concern)

Biodiversity Management Considerations

Where the primary conservation objective is to maintain biodiversity in northern hardwood swamps, the best management practice is to leave large tracts unharvested and allow natural processes (e.g., flooding, windthrow, and senescence) to operate unhindered. Black ash is a slow growing species and is usually found with small diameters, under 25 cm DBH (10 in), and is therefore of minor commercial value. Black ash is, however, a component of northern Wisconsin and Upper Peninsula Michigan sawtimber production. Clear-cutting black ash swamps can cause the loss of the community type due to the rises in the water table resulting from decreased transpiration following tree removal.

Threats to northern hardwood swamps involve hydrological impacts such as drainage for agriculture, sedimentation due to logging or construction, or the deleterious impacts of stormwater or wastewater runoff either causing prolonged flooding outside the natural range of variation, or significantly increasing nutrient levels and facilitating establishment of invasive species. Invasive species that may threaten the diversity and community structure of northern hardwood swamp include glossy buckthorn (*Rhamnus frangula*), purple loosestrife (*Lythrum salicaria*), narrow-leaved cat-tail (*Typha angustifolia*), hybrid cat-tail (*Typha xglauca*), reed (*Phragmites australis*), reed canary grass (*Phalaris arundinacea*), and European marsh thistle (*Cirsium palustre*). Regular monitoring for these and other invasive species followed by prompt and sustained control efforts will help protect the ecological integrity of northern hardwood swamp and adjacent natural communities.

In southern Lower Michigan, the introduction of the emerald ash borer (*Agilus planipennis*) has initiated new concern for ecosystems in which ash plays a significant role. The emerald ash borer (EAB), established in southeastern Lower Michigan around 1990, infests and kills all species of ash. Like Dutch elm disease, which has virtually eliminated American elm as a dominant overstory tree of swamp communities, EAB is having a similar effect on southern hardwood swamps and floodplain forests dominated by black or green ash. Outside the main area of infestation in southeastern Michigan, the density and health of ash is relatively robust, which will likely foster the expansion EAB throughout Michigan and into adjacent states and provinces.

Variation

Northern hardwood swamps occurring on lakeplains tend to be larger than those found in kettle depressions, which are limited in area by the size of the glacial ice-block that formed the basin.

Similar Natural Communities

Southern hardwood swamp, hardwood-conifer swamp, northern shrub thicket, and floodplain forest.

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For a full list of references used to create this description, please refer to the natural community abstract for northern hardwood swamp.

Southern Hardwood Swamp

Global/State Rank: G3/S3

Overview

Southern hardwood swamp is a minerotrophic forested wetland occurring in southern Lower Michigan on mineral or occasionally organic soils dominated by a mixture of lowland hardwoods. Conifers are absent or local. The community occupies shallow depressions and high-order stream drainages on a variety of landforms. The canopy is typically dominated by silver maple (*Acer saccharinum*), red maple (*A. rubrum*), green ash (*Fraxinus pennsylvanica*), and black ash (*Fraxinus nigra*).

Landscape Context

Southern hardwood swamp occurs in poorly drained depressions on glacial lakeplain, outwash plains and channels, end moraines, till plains, and perched dunes. Historically, the Maumee Lake Plain in southeastern Michigan supported large areas of lowland hardwood forest that bordered lakeplain prairie, lakeplain oak openings, wet-mesic flatwoods, and mesic southern forest. In large wetland complexes, southern hardwood swamp is typically associated with a variety of other herbaceous, shrub, and forested wetland communities. Upland communities bordering southern hardwood swamp are usually forested, with mesic southern forest being most common.

Soils

Soils are typically loam or silt loam, sometimes sandy loam or clay loam, of neutral to mildly alkaline pH (sandy substrates are more acidic), and sometimes covered by a thin layer of muck. An underlying impermeable clay lens is often present and allows for prolonged pooling of water. Occasionally the community occurs on deep sapric peat, especially inland, where stands may be associated with conifer or hardwood-conifer, minerotrophic peatlands.

Natural Processes

Water levels fluctuate seasonally, with standing water typically occurring throughout winter and spring. Due to anaerobic conditions associated with prolonged inundation and a high water table, trees are shallowly rooted and prone to frequent blowdown. Windthrow creates a pit and mound microtopography, and variously sized canopy gaps, which promote regeneration of a diverse overstory. In addition, the pit and mound microtopography generates fine-scale gradients of soil moisture and soil chemistry and provides a diversity of microsites for plant establishment. As spring floodwater drains, both the residual mucky pools and exposed tip-up mounds provide different habitat conditions, fostering high plant diversity. Coarse woody debris, which typically lies above the zone of flooding, remains a continued source of saturated substrate for seed germination and seedling establishment through drier periods. Prolonged flooding, often associated with beaver activity, leads to tree mortality and dominance by light-requiring shrubs and ground flora, typically sedges and grasses. Groundwater seepage affects species composition and structure. Fire is likely rare to infrequent, but may impact some stands in periods of extended drought, particularly in areas characterized by fire-dependent upland natural communities (e.g., oak barrens).

Vegetation

Dominance patterns vary, based largely on substrate characteristics, hydrology, and regional floristic distribution patterns. Sites on mineral soil that experience significant periods of inundation and seasonal water level fluctuation are typically dominated by silver maple and green

ash (*Fraxinus pennsylvanica*), with red maple and pin oak (*Quercus palustris*) often as important subdominants. Tree species typical of floodplain forest are often present, including hackberry (*Celtis occidentalis*), sycamore (*Platanus occidentalis*), and cottonwood (*Populus deltoides*). Other associates include sugar maple (*Acer saccharum*), white ash (*Fraxinus americana*), black ash (*F. nigra*), tulip tree (*Liriodendron tulipifera*), quaking aspen (*Populus tremuloides*), swamp white oak (*Quercus bicolor*), bur oak (*Q. macrocarpa*), red oak (*Q. rubra*), basswood (*Tilia americana*), and American elm (*Ulmus americana*). Prior to the introduction and spread of Dutch elm disease, American elm was an important canopy constituent, but is now largely relegated to the subcanopy and sapling layers. Other common understory species include saplings of canopy tree species (especially silver and red maple), musclewood (*Carpinus caroliniana*), and witch-hazel (*Hamamelis virginiana*). Characteristic shrub species include spicebush (*Lindera benzoin*), elderberry (*Sambucus canadensis*), winterberry (*Ilex verticillata*), and buttonbush (*Cephalanthus occidentalis*). The ground layer is characteristically sparse due to prolonged inundation during the early growing season. Commonly encountered species include false nettle (*Boehmeria cylindrica*), marsh marigold (*Caltha palustris*), spring cress (*Cardamine bulbosa*), pink spring cress (*C. douglassii*), fowl manna grass (*Glyceria striata*), jewelweed (*Impatiens capensis*), swamp buttercup (*Ranunculus hispidus*), bishop's cap (*Mitella diphylla*), wild geranium (*Geranium maculatum*), dwarf raspberry (*Rubus pubescens*), spinulose woodfern (*Dryopteris carthusiana*), cinnamon fern (*Osmunda cinnamomea*), sedges (*Carex gracillima*, *C. intumescens*, *C. radiata*, and *C. stipata*), poison ivy (*Toxicodendron radicans*), and Virginia creeper (*Parthenocissus quinquefolia*).

Sites on saturated organic soil of relatively stable hydrology are typically dominated by red maple and black ash. Common canopy associates include yellow birch (*Betula alleghaniensis*) and American elm; occasional associates include sugar maple, silver maple, American beech (*Fagus grandifolia*), white ash, green ash, tulip tree, quaking aspen, swamp white oak, sycamore, and basswood. Stands associated with hardwood-conifer swamp or rich tamarack swamp may occasionally contain scattered individuals of tamarack (*Larix laricina*), white pine (*Pinus strobus*), hemlock (*Tsuga canadensis*), or northern white-cedar (*Thuja occidentalis*). The subcanopy and tall shrub layers can range from open to closed, depending on canopy closure. The shrub layer is characterized by saplings of canopy species, in addition to musclewood, winterberry, poison ivy, nannyberry (*Viburnum lentago*), silky dogwood (*Cornus amomum*), gray dogwood (*C. foemina*), spicebush, elderberry, smooth highbush blueberry (*Vaccinium corymbosum*), and occasionally buttonbush in the most open and wettest swales. The ground layer ranges from sparse under the dense shade of hardwoods or in areas subject to seasonal inundation to dense in light gaps and openings. Stands are often characterized by the development of moss and litter-covered hummocks that are elevated above the saturated or inundated muck hollows. Characteristic species of hummocks and decomposing wood include spinulose woodfern (*Dryopteris carthusiana*), goldthread (*Coptis trifolia*), bishop's cap, Canada mayflower (*Maianthemum canadense*), and dwarf raspberry. Typical species of hollows and open, mucky flats include skunk cabbage (*Symplocarpus foetidus*), pink spring cress, spring cress, jack-in-the-pulpit (*Arisaema triphyllum*), marsh marigold, fowl manna grass, sedges (*Carex radiata*, *C. intumescens*, *C. stipata*, etc.), northern bugle weed (*Lycopus uniflorus*), false nettle (*Boehmeria cylindrica*), marsh fern (*Thelypteris palustris*), cinnamon fern, sensitive fern (*Onoclea sensibilis*), jewelweed, and clearweed (*Pilea* spp.) Areas of standing water are sometimes dominated by small duckweed (*Lemna minor*) or in the spring, by golden saxifrage (*Chrysosplenium americanum*).

Noteworthy Animals

Beaver (*Castor canadensis*) can cause prolonged flooding that substantially alters wetland community structure, converting southern hardwood swamps to a broad range of wetland types, depending on landscape position, soils, and depth and duration of flooding.

Rare Plants

Betula populifolia (gray birch, state special concern)
Betula murrayana (Murray birch, state special concern)
Carex lupuliformis (false hop sedge, state threatened)
Carex seorsa (sedge, state threatened)
Carex straminea (straw sedge, state endangered)
Cuscuta glomerata (rope dodder, state special concern)
Cuscuta polygonorum (knotweed dodder, state special concern)
Dryopteris celsa (log fern, state threatened)
Eupatorium fistulosum (hollow-stemmed joe-pye-weed, state threatened)
Fraxinus profunda (pumpkin ash, state threatened)
Galearis spectabilis (showy orchis, state threatened)
Glyceria melicaria (slender manna grass, state threatened)
Hybanthus concolor (green violet, state special concern)
Hydrastis canadensis (goldenseal, state threatened)
Isotria medeoloides (smaller whorled pogonia, presumed extirpated from Michigan)
Isotria verticillata (whorled pogonia, state threatened)
Lysimachia hybrida (swamp candles, presumed extirpated from Michigan)
Panax quinquefolius (ginseng, state threatened)
Panicum microcarpon (small-fruited panic grass, state special concern)
Plantago cordata (heart-leaved plantain, state endangered)
Poa paludigena (bog bluegrass, state threatened)
Polymnia uvedalia (large-flowered leafcup, state threatened)
Populus heterophylla (swamp or black cottonwood, state endangered)
Rudbeckia subtomentosa (sweet coneflower, presumed extirpated from Michigan)
Trillium undulatum (painted trillium, state endangered)
Valerianella umbilicata (corn-salad, state threatened)
Viburnum prunifolium (black haw, state special concern)
Woodwardia areolata (netted chain-fern, presumed extirpated from Michigan)

Rare Animals

Acronicta falcata (corylus dagger moth, state special concern)
Ambystoma opacum (marbled salamander, state endangered)
Ambystoma texanum (smallmouth salamander, state endangered)
Basilodes pepita (gold moth, state special concern)
Buteo lineatus (red-shouldered hawk, state threatened)
Catocala illecta (Magdalen underwing, state special concern)
Clemmys guttata (spotted turtle, state threatened)
Clonophis kirtlandii (Kirtland's snake, state endangered)
Emydoidea blandingii (Blanding's turtle, state special concern)
Euphyes dukesi (Dukes' skipper, state threatened)
Gomphus quadricolor (rapids clubtail, state special concern)
Haliaeetus leucocephalus (bald eagle, state special concern)
Heterocampa subrotata (small heterocampa, state special concern)
Heteropacha rileyana (Riley's lappet moth, state special concern)
Incisalia henrici (Henry's elfin, state threatened)

Myotis sodalis (Indiana bat, federal/state endangered)
Nerodia erythrogaster neglecta (copperbelly watersnake, federal threatened and state endangered)
Nycticorax nycticorax (black-crowned night-heron, state special concern)
Pandion haliaetus (osprey, state special concern)
Papaipema cerina (golden borer, state special concern)
Papaipema speciosissima (regal fern borer, state special concern)
Protonotaria citrea (prothonotary warbler, state special concern)
Seiurus motacilla (Louisiana waterthrush, state threatened)
Sistrurus c. catenatus (eastern massasauga, federal candidate species and state special concern)
Terrapene c. carolina (eastern box turtle, state special concern)

Biodiversity Management Considerations

Conservation of wetlands requires management and protection of adjacent upland communities aimed at maintaining hydrology, minimizing inputs of nutrient-rich runoff, and protecting and managing habitat for animal species that require both upland and wetland habitats. Hydrologic alteration associated with agriculture, roads, or other development can alter species composition and structure, and foster establishment of invasive species. Where the primary conservation objective is to maintain biodiversity in southern hardwood swamps, the best management is to leave large tracts unperturbed and allow natural processes such as flooding, windthrow, and senescence to operate unhindered.

Monitoring and control efforts to detect and remove invasive species are critical to the long-term viability of southern hardwood swamp. Invasive plant species that threaten the diversity and community structure include garlic mustard (*Alliaria petiolata*), reed canary grass (*Phalaris arundinacea*), reed (*Phragmites australis*), autumn olive (*Elaeagnus umbellata*), multiflora rose (*Rosa multiflora*), and glossy buckthorn (*Rhamnus frangula*). Light-requiring invasive plant species such as reed and reed canary grass can establish in canopy gaps and in openings along streams. Emerald ash borer, an invasive insect, has reduced or eliminated ash as an important component of upland and lowland forest types in southeastern Michigan and has the potential to significantly impact ash populations in forested wetlands and uplands throughout the state.

Variation

Dominance patterns among common canopy constituents vary based on site-specific factors. Silver maple and green ash indicate fluctuating hydrology and seasonal inundation, whereas areas dominated by red maple and black ash indicate a more stable hydrology influenced by persistent groundwater seepage. Stands that contain conifers may represent converted hardwood-conifer swamp, rich tamarack swamp, or rich conifer swamp. Conversion of conifer-dominated stands to hardwood dominance is frequently associated with anthropogenic disturbances such as logging, hydrologic alteration, and fire suppression. Small forested seeps embedded in a matrix of dry-mesic and mesic southern forest in southern Lower Michigan are currently placed in this classification, and sometimes include species otherwise absent in mixed hardwood swamp, including Ohio buckeye (*Aesculus glabra*), pawpaw (*Asimina triloba*), blue ash (*Fraxinus quadrangulata*), and hackberry.

Similar Natural Communities

Hardwood-conifer swamp, northern hardwood swamp, floodplain forest, and wet-mesic flatwoods.

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For a full list of references used to create this description, please refer to the natural community abstract for southern hardwood swamp.

Floodplain Forest

Global/State Rank: G3?/S3

Overview

Floodplain forest is a bottomland, deciduous or deciduous-conifer forest community occupying low-lying areas adjacent to streams and rivers of third order or greater, and subject to periodic over-the-bank flooding and cycles of erosion and deposition. Species composition and community structure vary regionally and are influenced by flooding frequency and duration. Silver maple (*Acer saccharinum*) and green ash (*Fraxinus pennsylvanica*) are typically major overstory dominants. Floodplain forests occur along major rivers throughout the state, but are most extensive in the Lower Peninsula. Species richness is greatest in the southern Lower Peninsula, where many floodplain species reach the northern extent of their range.

Landscape Context

Floodplain forests are located along streams and rivers of third order or greater. River floodplains occur within the four major physiographic systems (landforms) of Michigan: moraine, outwash plain, ice-contact terrain, and lakeplain. However, because the present drainage system is closely associated with drainage patterns that developed during the retreat of the Wisconsinan glaciers, river floodplains most frequently occur within former glacial meltwater (outwash) channels. River floodplains occur within broad outwash plains as well as narrow outwash plains situated between end moraines, and the river channels occasionally cut through moraines. In glacial lakeplains, large stretches of rivers flow through sand channels that formed where glacial meltwater carried and deposited sand into the proglacial lakes, but other stretches cut through fine silty and clayey lacustrine sediments.

Soils

Soil is highly variable and strongly correlated with fluvial landforms. The coarsest sediment is deposited on the natural levee, immediately adjacent to the stream channel, where the soil texture is often sandy loam to loam. Progressively finer soil particles are deposited with increasing distance from the stream. Soil texture of the first bottom is often silt loam, with silty clay loam to clay-textured soil often occurring in swales and backswamps. Cycles of periodic over-the-bank flooding followed by soil aeration when the floodwaters recede generally prevent the accumulation of organic soils. However, an accumulation of sapric peat can develop farther from the river due to a relatively low flood frequency, low flow velocity, and prolonged soil saturation resulting from a high water table. Floodplain soils are generally circumneutral to mildly alkaline. Slightly acid soils are generally only found on hummocks of organic soil in backswamps or meander-scar swamps. Floodplain soils are characterized by high nutrient availability and an abundance of soil water throughout much of the growing season.

Natural Processes

Direct interaction between terrestrial and aquatic ecosystems occurs in floodplain forests through the processes of over-the-bank flooding, bank cutting, and sedimentation. Over-the-bank flooding can directly cause treefall or indirectly lead to windthrow through increased soil saturation. Spring floodwaters often carry ice floes and debris that can scour trees, leading to the development of multiple-stemmed canopy trees. The input of organic matter from the floodplain forest provides sources of energy for aquatic organisms. Shade from streamside vegetation moderates temperature regimes in aquatic systems, preventing excessive warming of the river during summer months. Woody debris from floodplain vegetation influences the development of

channel morphology and provides necessary habitat for many aquatic organisms. Riparian vegetation reduces overland water flow and sediment transport. Nutrient uptake by floodplain vegetation and denitrification by soil bacteria decrease terrestrial inputs of nutrients into aquatic systems. Such processes are especially important in landscapes dominated by agricultural or urban land cover, where nutrient input from upland ecosystems is typically high.

The dynamic process of channel migration creates a diversity of landscape features in floodplains. Hydrogeomorphic processes such as over-the-bank flooding, transport and deposition of sediment, and erosive and abrasive water movement cause the floodplains of large rivers to exhibit a variety of fluvial landforms, each of which is associated with a particular kind of vegetation. Such fluvial landforms are distinguished by their size, shape, elevation, soil characteristics, and location in relation to the stream channel. Several of the most characteristic fluvial landforms are natural levee, first bottom, backswamp, oxbow, and terrace. A key series of relationships link the physiography of the river valley with that of the upland landscape. Basin size, topographic relief, and geologic parent material of the upland landscape determine river discharge, river grade, sediment load, and sediment type. These factors strongly influence the formation of fluvial landforms through the hydrogeomorphic processes of erosion, deposition, and channel migration. The size, shape, and diversity of fluvial landforms in a river floodplain and their spatial pattern are the result of the interaction between a river and the local landscape. Because physiographic systems are characterized by their topographic form and parent material, floodplains within different physiographic systems are characterized by differences in stream gradient, channel pattern, local hydrology, and fluvial landforms. When a river flows through a flat region, such as a broad outwash plain or a lakeplain, a wide, continuous floodplain develops. Within these wide floodplains, extensive lateral channel migration and the deposition of progressively finer-textured sediment with increasing distance from the river lead to the formation of a variety of fluvial landforms. With uniformly low topography and a relatively high water table, the broad first bottom of rivers within outwash plains and lakeplains is periodically inundated during the growing season. In contrast, both the higher topographic relief and finer-textured parent material of moraines encourage the development of narrow river valleys with more restricted floodplains and a reduced duration of flooding. The development of narrow valleys also occurs where rivers occupy narrow outwash channels situated between end moraines. The high topographic relief, relatively steep slope gradients, and fine-textured soil of morainal landscapes restrict lateral channel migration, resulting in narrow, sinuous floodplains that are frequently dissected by a series of higher terraces. The frequency of over-the-bank flooding in morainal landscapes is generally less than that in outwash plains and lakeplains. Instead, groundwater plays a stronger role, and constant soil saturation due to groundwater seepage often results in localized accumulations of organic soil.

Vegetation

As a result of the dynamic, local nature of natural disturbance along stream channels, a typical floodplain forest consists of many small patches of vegetation with different species composition, and successional stages often correlated with fluvial landforms. Within a single floodplain forest, vegetation changes along a gradient of flooding frequency and duration. In addition to local variation in species composition and structure within a site, there are major regional differences in species composition between floodplain forests in northern and southern Michigan. In both regions, dominant tree species nearly always include silver maple and green ash. Previously, American elm (*Ulmus americana*) was also a major dominant, but it has been largely eliminated from the canopy by Dutch elm disease. Numerous other species can be important, especially in the southernmost watersheds, resulting in complex patterns of species dominance.

Characteristic ground flora in southern Michigan include wild ginger (*Asarum canadense*), wood nettle (*Laportea canadensis*), stinging nettle (*Urtica dioica*), green dragon (*Arisaema dracontium*), purple meadow rue (*Thalictrum dasycarpum*), bluejoint grass (*Calamagrostis canadensis*), Virginia wild rye (*Elymus virginicus*), false nettle (*Boehmeria cylindrica*), carrion flower (*Smilax ecirrhata*), starry false Solomon's seal (*Smilacina stellata*), lizard's tail (*Saururus cernuus*), Gray's sedge (*Carex grayi*), Muskingum sedge (*C. muskingumensis*), wood reedgrass (*Cinna arundinacea*), southern blue flag (*Iris virginica*), clearweed (*Pilea pumila*), swamp buttercup (*Ranunculus hispidus*), golden ragwort (*Senecio aureus*), ostrich fern (*Matteuccia struthiopteris*), sensitive fern (*Onoclea sensibilis*), jewelweed (*Impatiens capensis*), skunk cabbage (*Symplocarpus foetidus*), late goldenrod (*Solidago gigantea*), and fringed loosestrife (*Lysimachia ciliata*). Compared to southern Michigan floodplains, grasses and sedges account for a larger portion of the ground flora in floodplains of northern Michigan. Grasses and sedges common to both northern and southern floodplain forests include bluejoint grass, Virginia wild rye, cut grass (*Leersia oryzoides*), fowl manna grass (*Glyceria striata*), lake sedge (*Carex lacustris*), great bladder sedge (*C. intumescens*), hop sedge (*C. lupulina*), and fringed sedge (*C. crinita*).

Fluvial landforms, defined by their size, shape, elevation, soil, and position in relation to the stream channel, exert a strong influence on the patterning of floodplain vegetation. New land deposits immediately adjacent to the stream channel are dominated by black willow (*Salix nigra*) and cottonwood (*Populus deltoides*). The natural levee is often dominated by silver maple and green ash, but a variety of additional tree species may also be common, including basswood (*Tilia americana*), swamp white oak (*Q. bicolor*), bur oak (*Q. macrocarpa*), sycamore (*Platanus occidentalis*), hackberry (*Celtis occidentalis*), box elder (*Acer negundo*), and shagbark hickory (*Carya ovata*). The low frequency and short duration of flooding on the levee and second bottom result in dense cover of shrubs and small trees such as musclewood (*Carpinus caroliniana*), alternate-leaved dogwood (*Cornus alternifolia*), gray dogwood (*C. foemina*), prickly ash (*Zanthoxylum americanum*), redbud (*Cercis canadensis*), hawthorns (*Crataegus* spp.), spicebush (*Lindera benzoin*), nannyberry (*Viburnum lentago*), elderberry (*Sambucus canadensis*), bladdernut (*Staphylea trifolia*), and choke cherry (*Prunus virginiana*). Adjacent to the levee, the first bottom flat is flooded more frequently and for a longer period, limiting the tree canopy to silver maple, green ash, and American elm. Shrubs are typically rare within the first bottom flat, but vines including riverbank grape (*Vitis riparia*), poison ivy (*Toxicodendron radicans*), Virginia creeper (*Parthenocissus quinquefolia*), and moonseed (*Menispermum canadense*) may be abundant. Small depressions and swales where tree canopy coverage is low are often dominated by buttonbush (*Cephalanthus occidentalis*). Second bottoms are typically dominated by the same tree species common to the levee but can also include bitternut hickory (*Carya cordiformis*), butternut (*Juglans cinerea*), black walnut (*J. nigra*), black maple (*Acer nigrum*), and white ash (*Fraxinus americana*). Shrubs may also be abundant on second bottoms. Areas where organic soil accumulates, such as groundwater seepages, backswamps, and meander-scar swamps are often dominated by black ash (*Fraxinus nigra*), yellow birch (*Betula alleghaniensis*), red maple (*Acer rubrum*), tamarack (*Larix laricina*), northern white-cedar (*Thuja occidentalis*), white pine (*Pinus strobus*), and hemlock (*Tsuga canadensis*), with conifer coverage especially high in the northern part of the state and often lacking in southern Lower Michigan. Species such as royal fern (*Osmunda regalis*), dwarf raspberry (*Rubus pubescens*), and New York fern (*Thelypteris noveboracensis*) are often abundant in the ground cover of these fluvial landforms. Low terraces, within the floodplain but above the influence of floodwaters, are often dominated by American beech (*Fagus grandifolia*) and sugar maple (*Acer saccharum*), often with black maple in the southern Lower Peninsula and hemlock in the northern Lower and Upper Peninsulas. Higher terraces are dominated by oak and hickory in the southern part of the state, and oak and pine in the north.

Noteworthy Animals

Large contiguous tracts of old-growth and mature floodplain forest provide important habitat for cavity nesters, species of detritus-based food webs, canopy-dwelling species, and interior forest obligates, including numerous neotropical migrants such as black-throated green warbler (*Dendroica virens*), scarlet tanager (*Piranga olivacea*), and ovenbird (*Seiurus aurocapillus*). Floodplain forests in Michigan support disproportionately large numbers of breeding bird species compared to upland landscapes and provide critical habitat for species closely associated with wetlands, including several rare species such as yellow-throated warbler (*Dendroica dominica*, state threatened), prothonotary warbler (*Protonotaria citrea*, state special concern), and Louisiana waterthrush (*Seiurus motacilla*, state threatened). Indiana bat (*Myotis sodalis*, federal/state endangered) establishes roosts and nurseries in standing snags within floodplain forests. Great blue heron (*Ardea herodias*) often construct rookeries within floodplain forests. Seasonally inundated portions of floodplains provide crucial habitat for reptiles and amphibians.

Rare Plants

Arabis perstellata (rock cress, state threatened)
Aristolochia serpentaria (Virginia snakeroot, state threatened)
Aster furcatus (forked aster, state threatened)
Bromus nottowayanus (satin brome, state special concern)
Camassia scilloides (wild-hyacinth, state threatened)
Carex assiniboinensis (Assiniboia sedge, state threatened)
Carex conjuncta (sedge, state threatened)
Carex crus-corvi (raven's-foot sedge, state endangered)
Carex davisii (Davis' sedge, state threatened)
Carex decomposita (log sedge, state threatened)
Carex haydenii (Hayden's sedge, presumed extirpated from Michigan)
Carex lupuliformis (false hop sedge, state threatened)
Carex oligocarpa (eastern few-fruited sedge, state threatened)
Carex squarrosa (squarrose sedge, state special concern)
Carex trichocarpa (hairy-fruited sedge, state special concern)
Carex typhina (cat-tail sedge, state threatened)
Chasmanthium latifolium (wild oats, state endangered)
Chelone obliqua (purple turtlehead, state endangered)
Corydalis flavula (yellow fumewort, state threatened)
Dasistoma macrophylla (mullein foxglove, state endangered)
Dentaria maxima (large toothwort, state threatened)
Diarrhena americana (beak grass, state threatened)
Dryopteris celsa (log fern, state threatened)
Euonymus atropurpurea (burning bush or wahoo, state special concern)
Fraxinus profunda (pumpkin ash, state threatened)
Galearis spectabilis (showy orchis, state threatened)
Gentianella quinquefolia (stiff gentian, state threatened)
Hybanthus concolor (green violet, state special concern)
Hydrastis canadensis (goldenseal, state threatened)
Jeffersonia diphylla (twinleaf, state special concern)
Justicia americana (water-willow, state threatened)
Lithospermum latifolium (broad-leaved puccoon, state special concern)
Lycopus virginicus (Virginia water horehound, state threatened)
Mertensia virginica (Virginia bluebells, state endangered)
Mikania scandens (climbing hempweed, presumed extirpated from Michigan)
Morus rubra (red mulberry, state threatened)

Panax quinquefolius (ginseng, state threatened)
Plantago cordata (heart-leaved plantain, state endangered)
Poa paludigena (bog bluegrass, state threatened)
Polemonium reptans (Jacob's ladder, state threatened)
Pycnanthemum pilosum (hairy mountain mint, state threatened)
Rudbeckia subtomentosa (sweet coneflower, presumed extirpated from Michigan)
Ruellia strepens (smooth ruellia, state endangered)
Scutellaria nervosa (skullcap, state endangered)
Scutellaria ovata (heart-leaved skullcap, state threatened)
Silphium perfoliatum (cup-plant, state threatened)
Trillium nivale (snow trillium, state threatened)
Trillium recurvatum (prairie trillium, state threatened)
Trillium sessile (toadshade, state threatened)
Valerianella chenopodiifolia (goosefoot corn-salad, state threatened)
Valerianella umblicata (corn-salad, state threatened)
Viburnum prunifolium (black haw, state threatened)
Wisteria frutescens (wisteria, state threatened)

Rare Animals

Ambystoma opacum (marbled salamander, state endangered)
Ambystoma texanum (smallmouth salamander, state endangered)
Buteo lineatus (red-shouldered hawk, state threatened)
Clonophis kirtlandii (Kirtland's snake, state endangered)
Dendroica cerulea (cerulean warbler, state threatened)
Dendroica dominica (yellow-throated warbler, state threatened)
Dryobius sexnotatus (six-banded longhorn beetle, state threatened)
Emydoidea blandingii (Blanding's turtle, state special concern)
Glyptemys insculpta (wood turtle, state special concern)
Mesodon elevatus (proud globe, state threatened)
Myotis sodalis (Indiana bat, federal/state endangered)
Nerodia erythrogaster neglecta (copperbelly watersnake, federal threatened and state endangered)
Protonotaria citrea (prothonotary warbler, state special concern)
Seiurus motacilla (Louisiana waterthrush, state threatened)
Sistrurus c. catenatus (eastern massasauga, federal candidate species and state special concern)
Tachopteryx thoreyi (grey petaltail, state threatened)
Terrapene c. carolina (eastern box turtle, state special concern)
Wilsonia citrina (hooded warbler, state special concern)

Rare Aquatic Animals

Acipenser fulvescens (lake sturgeon, state threatened)
Alasmidonta marginata (elktoe, state special concern)
Ammocrypta pellucida (eastern sand darter, state threatened)
Anguispira kochi (banded globe, state special concern)
Cyclonaias tuberculata (purple wartyback, state threatened)
Discus patulus (domed disc, state special concern)
Epioblasma torulosa rangiana (northern riffleshell, state endangered)
Epioblasma triquetra (snuffbox, state endangered)
Lampsilis fasciola (wavy-rayed lampmussel, state threatened)
Lepisosteus oculatus (spotted gar, state special concern)
Moxostoma carinatum (river redhorse, state threatened)

Noturus stigmosus (northern madtorn, state endangered)
Obovaria olivaria (hickorynut, state endangered)
Obovaria subrotunda (round hickorynut, state endangered)
Opsopoeodus emiliae (pugnose minnow, state endangered)
Percina copelandi (channel darter, state endangered)
Percina shumardi (river darter, state endangered)
Pleurobema clava (northern clubshell, state endangered)
Pleurobema sintoxia (round pigtoe, state special concern)
Pomatiopsis cincinnatiensis (brown walker, state special concern)
Simpsonaias ambigua (salamander mussel, state endangered)
Toxolasma lividus (purple lilliput, state endangered)
Venustaconcha ellipsiformis (ellipse, state special concern)
Villosa fabalis (rayed bean, state endangered)
Villosa iris (rainbow, state special concern)

Biodiversity Management Considerations

Successful conservation and management of floodplain forests can contribute significantly to regional biodiversity because these systems possess an unusually high diversity of plant and animal species, vegetation types, and ecological processes. By providing necessary hibernacula, breeding sites, foraging areas, and travel corridors, floodplain forests often support a high diversity of birds, herptiles, and mammals. Wider and more contiguous riparian systems support high levels of native plant species diversity compared to narrow, fragmented riparian systems. Riparian corridors may harbor twice the number of species than that found in adjacent upland areas.

Conservation and management of floodplain forests require an ecosystem management perspective because of the complex longitudinal, lateral, and vertical dimensions of river systems. It is crucial to maintain the connectivity and longitudinal environmental gradients from headwater streams to the broad floodplains located downstream. The natural spatial and temporal patterns of stream flow rates, water levels, and run-off patterns must be maintained or reestablished, where feasible, because these hydrologic processes create the diverse structure that characterizes floodplain forests. Maintaining vegetated buffers in the uplands bordering floodplain forests will help improve stream water quality. Restoration of channel morphology may be important in areas where stream channelization, channel constriction, and dams have altered water delivery and geomorphology. Conservation and restoration of fragmented floodplain forests also requires active long-term management to maintain deer at low densities.

Floodplain forests are highly susceptible to invasions by non-native species. Because of their linear shape and location between aquatic and terrestrial environments, floodplain forests have a high ratio of edge to interior habitat that may facilitate the movement of opportunistic species. Rivers and streams provide a route of transport that facilitates the spread of species across the landscape. Floodplain forests are highly and frequently disturbed systems that contain extensive areas of exposed mineral soil with high nutrient availability, characteristics that facilitate invasion by non-native species. Preemptive measures to minimize impacts of invasive species include maintaining mature floodplain forest, minimizing and eliminating trails and roads through floodplains, and buffering riparian areas with mature, continuous uplands. Once invasive species become established, control (through manual removal) becomes costly and intensive. Thus, monitoring and control efforts to detect and remove invasive species are critical to the long-term viability of floodplain forest. Some of the many invasive species that threaten the diversity and community structure of floodplains forests include garlic mustard (*Alliaria petiolata*), Dame's rocket (*Hesperis matronalis*), moneywort (*Lysimachia nummularia*), ground ivy (*Glechoma*

hederacea), purple loosestrife (*Lythrum salicaria*), narrow-leaved cat-tail (*Typha angustifolia*), hybrid cat-tail (*Typha xglauca*), reed (*Phragmites australis*), reed canary grass (*Phalaris arundinacea*), European marsh thistle (*Cirsium palustre*), glossy buckthorn (*Rhamnus frangula*), common buckthorn (*R. cathartica*), Eurasian honeysuckles (*Lonicera morrowii*, *L. japonica*, *L. maackii*, *L. sempervirens*, *L. tatarica*, *L. xbella*, and *L. xylosteum*), Japanese barberry (*Berberis thunbergii*), multiflora rose (*Rosa multiflora*), autumn olive (*Elaeagnus umbellata*), common privet (*Ligustrum vulgare*), white mulberry (*Morus alba*), and Norway maple (*Acer platanoides*). In addition to non-native plant species, non-native pathogens and insects have profoundly altered floodplain forests (e.g., Dutch elm disease and the emerald ash borer).

Throughout North America, almost all large rivers and their floodplains are subject to multiple hydrologic alterations, such as human-made levees, impoundments, channelization, dams, and changes in land use. By changing the flow of water, such hydrologic alterations interrupt flood pulses, which are critical in the dynamics of seed dispersal, plant establishment, nutrient cycling, channel scouring, sediment deposition, and the maintenance of species richness. Changes in land cover surrounding the floodplain have also altered species composition and structure within floodplain forests. Agricultural land cover in the adjacent uplands often leads to high-nutrient runoff entering the floodplain and stream, which lowers stream water quality. The abundance of impervious surface in urban landscapes often results in a flashy discharge into nearby rivers and degrades water quality.

Variation

Shifts in species composition occur gradually along a gradient from south to north, and to a lesser extent from lake-moderated areas along the coast to the interior of the state. Species richness is greatest in floodplains of the southern Lower Peninsula, where a number of species reach their northern extent. Conifers are typically absent from floodplains in the southern Lower Peninsula, though they may occur in groundwater seepages and meander-scar swamps, where organic soils accumulate. In northern Michigan, conifers often dominate backswamps, meander-scar swamps, and groundwater seepages. Compared to southern Michigan floodplains, grasses and sedges account for a larger portion of the ground flora in floodplains of northern Michigan.

Floodplains within outwash plains and lakeplains are typically broader and more continuous than floodplains in morainal landscapes. When a river flows through a broad outwash plain or a lakeplain, the low topographic gradient and high sand content of the bank promotes the development of broad first bottoms, where extensive channel migration leads to the formation of a variety of fluvial landforms, including natural levees, meander scrolls, oxbow lakes, backswamps, and meander-scar swamps. In contrast, when a river flows through a morainal landscape, the higher topographic relief, steeper slope gradients, and finer textured soil restrict channel migration, resulting in narrow floodplains that are often dissected by higher terraces. The frequency and duration of flooding are reduced, and the ridge and swale topography that characterizes first bottoms within outwash plains and lakeplains is usually lacking.

Similar Natural Communities

Hardwood-conifer swamp, mesic southern forest, mesic northern forest, northern hardwood swamp, and southern hardwood swamp.

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For a full list of references used to create this description, please refer to the natural community abstract for floodplain forest.

Wet-mesic Flatwoods

Global/State Rank: G2G3/S2

Overview

Wet-mesic flatwoods is a wet to mesic forest on mineral soils dominated by a highly diverse mixture of upland and lowland hardwoods. The community occurs almost exclusively on poorly drained glacial lakeplain in southeastern Lower Michigan. Dominant trees may include oaks, hickories, maples, ashes, and basswood. Seasonal inundation is the primary natural disturbance factor influencing wet-mesic flatwoods.

Landscape Context

Wet-mesic flatwoods occurs on low relief, poorly drained glacial lakeplain characterized by the presence of an impervious clay layer, or, locally, where similar conditions exist outside the glacial lakeplain.

Soils

Surface soils are typically medium to slightly acid sandy loam to loam and overlay mildly to moderately alkaline sandy clay loam, clay loam, or clay. An underlying impermeable clay lens is often present, which allows for prolonged pooling of water. Seasonal water level fluctuations lead to mottling of the mineral soil layers.

Natural Processes

Seasonal inundation due to low relief and the presence of an impervious clay layer leads to the development of a patchy, sparse ground layer. Water levels are typically highest in the late winter and spring, creating many vernal pools. Strong water level fluctuations over the growing season favor species otherwise typical of river and stream floodplains. Seasonally dry mineral soils allow for greater tree-rooting depth than in wetlands on organic soils, reducing the prevalence of windthrow. The role of fire in wet-mesic forests on the lakeplain is not well understood. Historically, where wet-mesic flatwoods bordered lakeplain prairies and lakeplain oak openings, surface fire likely spread through portions of the community when standing water was absent.

Vegetation

Wet-mesic flatwoods is characterized by a highly diverse tree canopy that reflects variations in soil moisture as a response to slight changes in surface topography and mineral soil composition across most sites. Canopy tree species may include both mesic and wetland species. Dominant trees are red oak (*Quercus rubra*), Shumard's oak (*Q. shumardii*, state special concern), white oak (*Q. alba*), swamp white oak (*Q. bicolor*), chinquapin oak (*Q. muehlenbergii*), pin oak (*Q. palustris*), bur oak (*Q. macrocarpa*), shagbark hickory (*Carya ovata*), bitternut hickory (*C. cordiformis*), shellbark hickory (*C. laciniosa*), American beech (*Fagus grandifolia*), sugar maple (*Acer saccharum*), black maple (*A. nigrum*), silver maple (*A. saccharinum*), red maple (*A. rubrum*), green ash (*Fraxinus pennsylvanica*), white ash (*F. americana*), pumpkin ash (*F. profunda*, state threatened), and basswood (*Tilia americana*). Very slight rises in topography are interspersed with lower, wet stands of swamp white oak, pin oak, red maple, silver maple, and green ash. In addition, tree species associated with floodplain forests may also be present, including cottonwood (*Populus deltoides*), sycamore (*Platanus occidentalis*), and hackberry (*Celtis occidentalis*). The state-listed tree species Shumard's oak and pumpkin ash may be dominant in some sites but absent from others. American elm (*Ulmus americana*) is an important understory component in most stands and likely was once an overstory dominant prior to the

introduction of Dutch elm disease. Other common species in the understory include saplings of canopy tree species (especially red and silver maple), musclewood (*Carpinus caroliniana*), ironwood (*Ostrya virginiana*), prickly ash (*Zanthoxylum americanum*), maple-leaved arrow-wood (*Viburnum acerifolium*), and spicebush (*Lindera benzoin*). The ground layer may be locally sparse due to frequent inundation. Species typical of both mesic forests and wetlands are present, including poison ivy (*Toxicodendron radicans*), enchanter's nightshade (*Circaea lutetiana*), jumpseed (*Polygonum virginianum*), clearweed (*Pilea pumila*), jack-in-the-pulpit (*Arisaema triphyllum*), May apple (*Podophyllum peltatum*), Gray's sedge (*Carex grayi*), great bladder sedge (*C. intumescens*), blue-stemmed goldenrod (*Solidago caesia*), broad-leaved goldenrod (*S. flexicaulis*), riverbank grape (*Vitis riparia*), and wild geranium (*Geranium maculatum*).

Noteworthy Animals

Vernal pools are abundant in wet-mesic flatwoods and serve as breeding ponds for aquatic invertebrates and amphibians. Today, these isolated forest stands are often completely surrounded by agriculture, old fields, and urban developments, and therefore provide critical habitat for cavity nesters, canopy-dwelling species, and interior forest obligates, including neotropical migrant birds such as black-throated green warbler (*Dendroica virens*), scarlet tanager (*Piranga olivacea*), and ovenbird (*Seiurus aurocapillus*).

Rare Plants

Carex lupuliformis (false hop sedge, state threatened)
Carex seorsa (sedge, state threatened)
Carex squarrosa (sugarrose sedge, state special concern)
Cuscuta glomerata (rope dodder, state special concern)
Cuscuta polygonorum (knotweed dodder, state special concern)
Dryopteris celsa (log fern, state threatened)
Eupatorium fistulosum (hollow-stemmed joe-pye-weed, state threatened)
Fraxinus profunda (pumpkin ash, state threatened)
Galearis spectabilis (showy orchis, state threatened)
Hydrastis canadensis (goldenseal, state threatened)
Isotria medeoloides (smaller whorled pogonia, presumed extirpated from Michigan)
Isotria verticillata (whorled pogonia, state threatened)
Panax quinquefolius (ginseng, state threatened)
Plantago cordata (heart-leaved plantain, state endangered)
Polymnia uvedalia (large-flowered leafcup, state threatened)
Populus heterophylla (swamp or black cottonwood, state endangered)
Quercus shumardii (Shumard's oak, state special concern)
Rudbeckia subtomentosa (sweet coneflower, presumed extirpated from Michigan)
Valerianella umbilicata (corn-salad, state threatened)
Viburnum prunifolium (black haw, state special concern)
Woodwardia areolata (netted chain-fern, presumed extirpated from Michigan)

Rare Animals

Acronicta falcata (Corylus dagger moth, state special concern)
Ambystoma opacum (marbled salamander, state endangered)
Ambystoma texanum (smallmouth salamander, state endangered)
Basilodes pepita (gold moth, state special concern)
Buteo lineatus (red-shouldered hawk, state threatened)
Catocala illecta (Magdalen underwing, state special concern)
Clemmys guttata (spotted turtle, state threatened)
Clonophis kirtlandii (Kirtland's snake, state endangered)

Emydoidea blandingii (Blanding's turtle, state special concern)
Euphyes dukesi (Dukes' skipper, state threatened)
Gomphus quadricolor (rapids clubtail, state special concern)
Haliaeetus leucocephalus (bald eagle, state special concern)
Heterocampa subrotata (small heterocampa, state special concern)
Heteropacha rileyana (Riley's lappet moth, state special concern)
Incisalia henrici (Henry's elfin, state threatened)
Myotis sodalis (Indiana bat, federal/state endangered)
Nerodia erythrogaster neglecta (copperbelly watersnake, federal threatened and state endangered)
Nycticorax nycticorax (black-crowned night-heron, state special concern)
Pandion haliaetus (osprey, state special concern)
Papaipema cerina (golden borer, state special concern)
Papaipema speciosissima (regal fern borer, state special concern)
Protonotaria citrea (prothonotary warbler, state special concern)
Seiurus motacilla (Louisiana waterthrush, state threatened)
Sistrurus c. catenatus (eastern massasauga, federal candidate species and state special concern)
Terrapene c. carolina (eastern box turtle, state special concern)

Biodiversity Management Considerations

Wet-mesic flatwoods have been significantly impacted by fragmentation and hydrologic disturbance associated with agricultural and urban development. An extensive system of drains and ditches on the southeastern Lower Michigan lakeplain has altered regional hydrology. Increasing urban development on the southeastern Michigan lakeplain threatens most of the known remnants of wet-mesic flatwoods. Restoring connectivity between isolated forest patches by either replanting forest or allowing old fields to succeed to forest will aid species dispersal and reduce edge effects.

Invasive species monitoring and removal efforts should be implemented in existing remnants of wet-mesic flatwoods. Invasive plants that may threaten diversity and community structure include garlic mustard (*Alliaria petiolata*), Dame's rocket (*Hesperis matronalis*), moneywort (*Lysimachia nummularia*), ground ivy (*Glechoma hederacea*), purple loosestrife (*Lythrum salicaria*), glossy buckthorn (*Rhamnus frangula*), common buckthorn (*R. cathartica*), Eurasian honeysuckles (*Lonicera morrowii*, *L. japonica*, *L. maackii*, *L. sempervirens*, *L. tatarica*, *L. xbella*, and *L. xylosteum*), Japanese barberry (*Berberis thunbergii*), multiflora rose (*Rosa multiflora*), autumn olive (*Elaeagnus umbellata*), common privet (*Ligustrum vulgare*), white mulberry (*Morus alba*), and Norway maple (*Acer platanoides*). In addition to invasive plant species, non-native pathogens and insects have profoundly affected wet-mesic flatwoods (e.g., Dutch elm disease and the emerald ash borer).

Variation

Dominance varies among several upland and wetland species; oaks are typically important. Stands on level lakeplain that are dominated by silver maple, red maple, green ash, and/or pin oak may be better classified as wet flatwoods, but this type has not yet been adequately surveyed and researched.

Similar Natural Communities

Mesic southern forest, southern hardwood swamp, lakeplain oak openings, floodplain forest, and northern hardwood swamp.

Relevant Literature

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For a full list of references used to create this description, please refer to the natural community abstract for wet-mesic flatwoods.

PALUSTRINE/TERRESTRIAL COMMUNITIES

Wooded Dune and Swale Complex

Global/State Rank: G3/S3

Overview

Wooded dune and swale complex is a large complex of parallel wetland swales and upland beach ridges (dunes) found in coastal embayments and on large sand spits along the shorelines of the Great Lakes. The upland dune ridges are typically forested, while the low swales support a variety of herbaceous or forested wetland types, with open wetlands more common near the shoreline and forested wetlands more prevalent farther from the lake. Wooded dune and swale complexes occur primarily in the northern Lower and Upper Peninsulas and Thumb region.

Landscape Context

Wooded dune and swale complexes are found in coastal embayments and on large sand spits along shorelines of the Great Lakes in Minnesota, Wisconsin, Michigan, Illinois, Pennsylvania, Ohio, and Ontario. They were formed in two stages by retreating water levels and post-glacial uplift beginning with glacial Lake Algonquin approximately 12,000 years ago. As lake levels progressively receded, they deposited a series of low, parallel, sandy beach ridges ranging in height from 0.5 m to 4.0 m. The alternating sequence of arced sand ridges and associated swales often extends up to two miles inland.

Soils

Given the complexity and variation of wooded dune and swale complexes, soils can range from calcareous sands in the foredunes to deep acidic peat or alkaline marl in well-established swales.

Natural Processes

Wooded dune and swale complexes formed as a result of receding Great Lakes water levels and post-glacial uplift that created a series of parallel, arced, low sand ridges and swales. Vegetative succession has since created a distinct pattern of communities or zones across this landscape complex. The flow of surface streams and groundwater is critical for maintaining saturated to inundated conditions in swales. Because of the proximity to the shoreline, windthrow is common, especially on the loose organic soils of swales where anaerobic conditions limit the rooting depth of trees. Along-shore currents, waves, and wind create and continuously re-work foredunes along the shoreline. Additional important components of the natural disturbance regime include fire, beaver flooding, and insect epidemics.

Vegetation

Wooded dune and swale complexes consist of a distinct series of successional vegetative zones or communities determined by factors such as distance from the lake, amount of soil development, groundwater input, and light availability. Component communities typically proceed from primary open dunes and interdunal wetlands along the shore to grassland, then shrubland, and finally forested dune ridges and swales farther inland. With increasing distance from the lakeshore, there is greater protection from wind and wave action and subsequently greater soil development and more complex natural communities.

Vegetation growing on the low foredunes along the shorelines commonly includes marram grass (*Ammophila breviligulata*), dune grass (*Calamovilfa longifolia*), autumn willow (*Salix serissima*), sand dune willow (*S. cordata*), and balsam poplar (*Populus balsamifera*).

Behind foredunes, where saturated lake-influenced, calcareous sands form the substrate, common species include twig-rush (*Cladium mariscoides*), sweet gale (*Myrica gale*), shrubby cinquefoil (*Potentilla fruticosa*), bluejoint grass (*Calamagrostis canadensis*), Kalm's lobelia (*Lobelia kalmii*), false asphodel (*Tofieldia glutinosa*), grass-of-Parnassus (*Parnassia glauca*), rushes (i.e., *Juncus balticus*, *J. pelocarpus*, and *J. nodosus*), spike-rush (*Eleocharis acicularis*), and three-square (*Schoenoplectus pungens*).

A low dune field is often present and typically supports a scattered overstory of jack pine (*Pinus banksiana*), white pine (*P. strobus*), and red pine (*P. resinosa*) and an understory and ground layer of common juniper (*Juniperus communis*), creeping juniper (*J. horizontalis*), bearberry (*Arctostaphylos uva-ursi*), marram grass, and June grass (*Koeleria macrantha*).

Inland of the dune field, both the dune ridges and swales are typically forested, although open, herbaceous wetlands may be common in the swales closer to the shoreline. Moist swales typically contain saturated organic soils and support partial to closed canopies of northern white-cedar (*Thuja occidentalis*), tag alder (*Alnus rugosa*), willows (*Salix spp.*), and red maple (*Acer rubrum*).

Swales where standing water is present through most of the year typically lack an overstory and instead are dominated by sedges (*Carex aquatilis* and *C. stricta*), twig-rush, marsh marigold (*Caltha palustris*), swamp candles (*Lysimachia terrestris*), sweet gale (*Myrica gale*), and marsh cinquefoil (*Potentilla palustris*). Where organic soils have accumulated to greater depths farther from the shoreline, vegetation in open swales may reflect more acid conditions and support species such as leatherleaf (*Chamaedaphne calyculata*), bog rosemary (*Andromeda glaucophylla*), Labrador tea (*Ledum groenlandicum*), bog laurel (*Kalmia polifolia*), large cranberry (*Vaccinium macrocarpon*), tawny cotton-grass (*Eriophorum virginicum*), pitcher-plant (*Sarracenia purpurea*), and sphagnum mosses (i.e., *Sphagnum centrale*, *S. wulfianum*, *S. warnstorffii*, *S. magellanicum*, and *S. squarrosum*). Shrub-dominated swales with scattered trees are also common and typically include species such as tag alder, black chokeberry (*Aronia prunifolia*), red-osier dogwood (*Cornus stolonifera*), bog birch (*Betula pumila*), as well as sedges (*Carex lasiocarpa*, *C. oligosperma*, *C. aquatilis*, and *C. stricta*), wool-grass (*Scirpus cyperinus*), and marsh fern (*Thelypteris palustris*).

Forested beach ridges tend to be dominated by species common to dry-mesic northern forest and mesic northern forest including red pine, white pine, and red oak (*Quercus rubra*). Subcanopy dominants often include paper birch (*Betula papyrifera*), big-toothed aspen (*Populus grandidentata*), balsam fir (*Abies balsamea*), and red maple. Common species of the shrub and ground layers of inland beach ridges include bracken fern (*Pteridium aquilinum*), huckleberry (*Gaylussacia baccata*), Canada blueberry (*Vaccinium myrtilloides*), bunchberry (*Cornus canadensis*), and wintergreen (*Gaultheria procumbens*).

On lower dune ridges, where soils are moister, white pine may share dominance with white spruce (*Picea glauca*), black spruce (*P. mariana*), red maple, balsam fir, northern white-cedar, and occasionally tamarack (*Larix laricina*). Common shrub and ground layer species on the lower dune ridges may include American fly honeysuckle (*Lonicera canadensis*), mountain holly (*Nemopanthus mucronata*), twinflower (*Linnaea borealis*), dwarf raspberry (*Rubus pubescens*), Canada mayflower (*Maianthemum canadensis*), and starflower (*Trientalis borealis*).

Noteworthy Animals

Beaver (*Castor canadensis*) can dam streams that flow through wooded dune and swale complexes, causing vegetation in affected swales to shift from forest to emergent marsh and northern wet meadow.

Rare Plants

Armoracia lacustris (lakecress, state threatened)
Carex albolutescens (greenish-white sedge, state threatened)
Carex nigra (black sedge, state endangered)
Calypso bulbosa (calypso, state threatened)
Cirsium pitcheri (Pitcher's thistle, state threatened)
Crataegus douglasii (Douglas's hawthorn, state special concern)
Cypripedium arietinum (ram's head lady's-slipper, state special concern)
Elymus glaucus (blue wild-rye, state special concern)
Elymus mollis (American dune wild-rye, state special concern)
Iris lacustris (dwarf lake iris, federal/state threatened)
Orobanche fasciculata (fascicled broom-rape, state threatened)
Pterospora andromedea (pine-drops, state threatened)
Ranunculus lapponicus (Lapland buttercup, state threatened)
Salix pellita (satiny willow, state special concern)
Solidago houghtonii (Houghton's goldenrod, federal/state threatened)
Stellaria longipes (stitchwort, state special concern)
Tanacetum huronense (Lake Huron tansy, state threatened)

Rare Animals

Accipiter gentilis (northern goshawk, state special concern)
Buteo lineatus (red-shouldered hawk, state threatened)
Canis lupus (gray wolf, federal endangered and state threatened)
Charadrius melodus (piping plover, federal/state endangered)
Euxoa aurulenta (dune cutworm, state special concern)
Falco columbarius (merlin, state threatened)
Haliaeetus leucocephalus (bald eagle, state special concern)
Lanius ludovicianus migrans (migrant loggerhead strike, state endangered)
Pandion haliaetus (osprey, state special concern)
Sistrurus c. catenatus (eastern massasauga, federal candidate species and state special concern)
Trimerotropis huroniana (Lake Huron locust, state threatened)

Biodiversity Management Considerations

Residential and recreational development and accompanying road building in and around wooded dune and swale complexes has resulted in disrupted hydrological conditions, wetland destruction, nutrient loading, and the introduction of invasive species. Conservation efforts should focus on protecting wooded dune and swale complexes from development and fragmentation, preserving natural hydrology, and controlling invasive species. Because of the wide diversity of habitats provided by wooded dune and swale complexes, invasive species that threaten the diversity and community structure include species from all ends of the moisture and light continuums.

Particularly aggressive invasives to monitor and promptly remove if found include garlic mustard (*Alliaria petiolata*), Dame's rocket (*Hesperis matronalis*), purple loosestrife (*Lythrum salicaria*), narrow-leaved cat-tail (*Typha angustifolia*), hybrid cat-tail (*Typha xglauca*), reed (*Phragmites australis*), reed canary grass (*Phalaris arundinacea*), European marsh thistle (*Cirsium palustre*), spotted knapweed (*Centaurea maculosa*), common buckthorn (*Rhamnus cathartica*), glossy buckthorn (*R. frangula*), autumn olive (*Elaeagnus umbellata*), Eurasian honeysuckles (*Lonicera*

morrowii, *L. japonica*, *L. maackii*, *L. sempervirens*, *L. tatarica*, *L. xbella*, and *L. xylosteum*), multiflora rose (*Rosa multiflora*), and Norway maple (*Acer platanoides*).

Variation

The following five sub-types of wooded dune and swale complexes have been identified based on differences in geographic location, processes of beach ridge formation, and plant assemblages: Southern Lake Huron; Northern Lake Huron/Lake Michigan-Low Dune; Northern Lake Michigan-High Dune; Lake Superior-High Dune; and Lake Superior-Low Dune.

Similar Natural Communities

Wooded dune and swale complexes may encompass several natural communities, including emergent marsh, northern wet meadow, northern shrub thicket, northern fen, poor fen, coastal fen, Great Lakes barrens, interdunal wetland, rich conifer swamp, poor conifer swamp, hardwood-conifer swamp, bog, dry northern forest, dry-mesic northern forest, mesic northern forest, open dunes, and sand and gravel beach.

Relevant Literature

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For a full list of references used to create this description, please refer to the natural community abstract for wooded dune and swale complex.

TERRESTRIAL COMMUNITIES

PRAIRIE COMMUNITIES

Dry Sand Prairie

Global/State Rank: G3/S2

Overview

Dry sand prairie is a native grassland community dominated by little bluestem (*Andropogon scoparius*), big bluestem (*Andropogon gerardii*), and Pennsylvania sedge (*Carex pensylvanica*). Vegetation is patchy and short in comparison to other prairie communities. The community occurs on loamy sands on well-drained to excessively well-drained, sandy glacial outwash plains and lakebeds both north and south of the climatic tension zone but is most common in northern Lower Michigan.

Landscape Context

Dry sand prairie occurs predominantly on the well-drained, nutrient-poor soils of sandy glacial outwash plains and lakebeds but may also occur on hilly, sandy deposits in ice-contact terrain and coarse-textured end and ground moraines. The lack of natural firebreaks on flat to gently rolling topography allows for broad-scale fires to carry across these landforms. Due to the variability of historic fires, dry sand prairies occurred as part of a shifting mosaic along with oak barrens in southern Michigan, oak-pine barrens in western Lower Michigan, and pine barrens or oak-pine barrens in northern Lower Michigan. Most of these former barrens communities have converted to forest as a result of fire suppression. Thus, dry sand prairies today are most commonly bordered by dry southern forest in the south, dry-mesic northern forest in western and northern Lower Michigan, or dry northern forest in central northern Lower Michigan.

Soils

Soils of dry sand prairies are typically very strongly acid to medium acid loamy sand with low water-retaining capacity.

Natural Processes

Historically, dry sand prairies were maintained in an open condition as a result of frequent fires, droughty soils, and in northern Lower Michigan, by frequent growing-season frosts. Fire frequency depended on a variety of factors such as type and volume of fuel, topography, and natural firebreaks. Prior to European settlement, intentional ignition by Native Americans and occasional lightning strikes were the main sources of fire. In addition to creating and maintaining the open conditions of dry sand prairies, frequent fires also help preserve species diversity by promoting seed germination and seedling establishment, creating microsites for small species, increasing the availability of plant nutrients, and bolstering flowering and seed set.

The excessively drained, sandy soils of dry sand prairie act to perpetuate open conditions by limiting tree establishment, especially during periodic droughts. Growing-season frosts, which also limit tree establishment, especially by hardwoods, are particularly common in the High Plains Subsection of northern Lower Michigan. In this region, dry sand prairie frequently occurs along with pine barrens in lower elevation, flat outwash plains known as frost pockets.

Vegetation

The vegetation of dry sand prairie is typically low to medium in height and somewhat sparse with patches of bare soil common. The community is dominated by little bluestem, Pennsylvania sedge, and big bluestem, with scattered trees maintained in a shrub-like condition (e.g., grubs) by frequent fires, droughty soils, and in northern Michigan, by growing-season frosts. Species composition varies by region.

Common species of dry sand prairie in the High Plains Subsection include the following: Pennsylvania sedge, poverty grass (*Danthonia spicata*), hair grass (*Deschampsia flexuosa*), little bluestem, June grass (*Koeleria macrantha*), rough-leaved rice grass (*Oryzopsis asperifolia*), rice grass (*Oryzopsis pungens*), rough fescue (*Festuca scabrella*, state threatened), big bluestem, rough blazing star (*Liatris aspera*), harebell (*Campanula rotundifolia*), Hill's thistle (*Cirsium hillii*, state special concern), pale agoseris (*Agoseris glauca*, state threatened), bearberry (*Arctostaphylos uva-ursi*), sand cherry (*Prunus pumila*), sweetfern (*Comptonia peregrina*), northern dewberry (*Rubus flagellaris*), low sweet blueberry (*Vaccinium angustifolium*), jack pine (*Pinus banksiana*), red pine (*Pinus resinosa*), and northern pin oak (*Quercus ellipsoidalis*). Oak grubs of white oak (*Quercus alba*), black oak (*Quercus velutina*), and northern pin oak can be abundant in dry sand prairie and may also occur as widely scattered, open grown adults. White pine (*Pinus strobus*), red pine (*Pinus resinosa*), and jack pine can occur in dry sand prairie as seedlings, saplings, and widely scattered adults.

The dominant vegetation of dry sand prairies in southern and western Lower Michigan includes the following species: little bluestem, Pennsylvania sedge, New Jersey tea (*Ceanothus americanus*), flowering spurge (*Euphorbia corollata*), wild strawberry (*Fragaria virginiana*), long-bearded hawkweed (*Hieracium longipilum*), tall lettuce (*Lactuca canadensis*), old-field goldenrod (*Solidago nemoralis*), big bluestem, smooth pussytoes (*Antennaria parlinii*), wormwood (*Artemisia campestris*), butterfly weed (*Asclepias tuberosa*), prairie heart-leaved aster (*Aster oolentangiensis*), poverty grass, common rockrose (*Helianthemum canadense*), rough blazing star, wild lupine (*Lupinus perennis*), panic grass (*Panicum oligosanthos*), northern dewberry, black-eyed Susan (*Rudbeckia hirta*), early goldenrod (*Solidago juncea*), and common spiderwort (*Tradescantia ohiensis*).

Noteworthy Animals

Ants, particularly the genus *Formica*, play an important role in mixing and aerating prairie soils as they continually build and abandon mounds, overturning large portions of prairie soil in the process. Other important species contributing to soil mixing and aeration include moles, mice, striped skunks (*Mephitis mephitis*), and badgers (*Taxidea taxus*). Kirtland's warbler (*Dendroica kirtlandii*, federal/state endangered) breeds almost exclusively in the matrix landscape of dry sand prairie, pine barrens, and dry-northern forest of northern Lower Michigan.

Rare Plants

Agoseris glauca (pale agoseris, state threatened)
Amorpha canescens (leadplant, state special concern)
Androsace occidentalis (rock-jasmine, state endangered)
Aristida dichotoma (Shiner's three-awned grass, presumed extirpated from Michigan)
Aristida tuberculosa (beach three-awned grass, state endangered)
Aster drummondii (Drummond's aster, state threatened)
Aster sericeus (western silvery aster, state threatened)
Carex gravida (sedge, presumed extirpated from Michigan)
Carex inops ssp. *heliophila* (sun sedge, state special concern)
Cirsium hillii (Hill's thistle, state special concern)

Digitaria filiformis (slender finger-grass, presumed extirpated from Michigan)
Eryngium yuccifolium (rattlesnake-master, state threatened)
Festuca scabrella (rough fescue, state threatened)
Geum triflorum (prairie-smoke, state threatened)
Liatrix punctata (dotted blazing-star, presumed extirpated from Michigan)
Linum sulcatum (furrowed flax, state special concern)
Lithospermum incisum (narrow-leaved puccoon, presumed extirpated from Michigan)
Panicum leibergii (Leiberg's panic grass, state threatened)
Penstemon pallidus (pale beard-tongue, state special concern)
Polygala incarnata (pink milkwort, presumed extirpated from Michigan)
Prunus alleghaniensis var. *davisii* (Alleghany plum, state special concern)
Ruellia humilis (hairy ruellia, state threatened)
Scleria pauciflora (few-flowered nut-rush, state endangered)
Scleria triglomerata (tall nut-rush, state special concern)
Solidago missouriensis (Missouri goldenrod, state threatened)
Tradescantia bracteata (long-bracted spiderwort, presumed extirpated from Michigan)
Tradescantia virginiana (Virginia spiderwort, state special concern)
Trichostema brachiatum (false pennyroyal, state threatened)
Trichostema dichotomum (bastard pennyroyal, state threatened)
Triplasis purpurea (sand grass, state special concern)
Vaccinium cespitosum (dwarf bilberry, state threatened)

Rare Animals

Ammodramus henslowii (Henslow's sparrow, state endangered)
Ammodramus savannarum (grasshopper sparrow, state special concern)
Appalachia arcana (secretive locust, state special concern)
Asio flammeus (short-eared owl, state endangered)
Asio otus (long-eared owl, state threatened)
Atrytonopsis hianna (dusted skipper, state special concern)
Clemmys guttata (spotted turtle, state threatened)
Dendroica kirtlandii (Kirtland's warbler, federal/state endangered)
Emydoidea blandingii (Blanding's turtle, state special concern)
Erynnis p. persius (Persius duskywing, state threatened)
Flexamia delongi (leafhopper, state special concern)
Glyptemys insculpta (wood turtle, state special concern)
Hesperia ottoe (Ottoe skipper, state threatened)
Incisalia irus (frosted elfin, state threatened)
Lanus ludovicianus migrans (migrant loggerhead shrike, state endangered)
Lepyronia gibbosa (Great Plains spittlebug, state special concern)
Lycaeides melissa samuelis (Karner blue, federal endangered and state threatened)
Microtus ochrogaster (prairie vole, state endangered)
Pantherophis spiloides (gray ratsnake, state special concern)
Papaipema beeriana (blazing star borer, state special concern)
Prosapia ignipectus (red-legged spittlebug, state special concern)
Pygarctia spraguei (Sprague's pygarctia, state special concern)
Pyrgus wyandot (grizzled skipper, state special concern)
Schinia indiana (phlox moth, state endangered)
Sistrurus c. catenatus (eastern massasauga, federal candidate species and state special concern)
Speyeria idalia (regal fritillary, state endangered)
Spiza americana (dickcissel, state special concern)
Sturnella neglecta (western meadowlark, state special concern)

Terrapene c. carolina (eastern box turtle, state special concern)

Tyto alba (barn owl, state endangered)

Biodiversity Management Considerations

Conservation priorities for dry sand prairies include identifying, protecting, and managing existing remnants where they occur. Managing dry sand prairie requires frequent prescribed burning to protect and enhance plant species diversity and prevent encroachment of trees and tall shrubs. In addition to prescribed fire, brush cutting accompanied by stump application of herbicide is often an important component of prairie restoration. To reduce the impacts of management on fire-intolerant species it is important to consider a rotating schedule of prescribed burns in which adjacent management units are burned in alternate years. Alternating burn units provides refugia for fire-intolerant insect species that are then able to recolonize the burned areas. Avian species diversity is also enhanced by managing large areas as a mosaic of burned and unburned patches. In addition, many restoration sites may require the reintroduction of appropriate native species and genotypes as small, isolated prairie remnants are subject to reduced gene flow.

Controlling invasive species is a critical step in restoring and managing dry sand prairie. By outcompeting native species, invasives alter vegetation structure, reduce species diversity, and disrupt ecological processes. Invasive plants such as Canada bluegrass (*Poa compressa*), Kentucky bluegrass (*P. pratensis*), sheep sorrel (*Rumex acetosella*), and hawkweeds (*Hieracium* spp.) can be ubiquitous within dry sand prairie remnants yet their impacts on overall species composition and diversity have not been well studied. These widespread invasive species likely outcompete many native forb seedlings for nutrients, water, and space, and thereby, along with lack of fire, perpetuate low levels of native forb abundance within dry sand prairie remnants. Additional invasive species that threaten the diversity and community structure of dry sand prairie include spotted knapweed (*Centaurea maculosa*), common St. John's-wort (*Hypericum perforatum*), leafy spurge (*Euphorbia esula*), hoary alyssum (*Berteroa incana*), autumn olive (*Elaeagnus umbellata*), common buckthorn (*Rhamnus cathartica*), Eurasian honeysuckles (*Lonicera maackii*, *L. morrowii*, *L. tatarica*, and *L. xbella.*), and black locust (*Robinia pseudoacacia*).

Variation

As described in the Vegetation section above, species composition varies across ecoregions. Dry sand prairies in the High Plains Subsection of north central Lower Michigan are subject to colder temperatures, growing-season frosts, and a shorter growing season than occurrences in southern Lower Michigan.

Similar Natural Communities

Dry-mesic prairie, hillside prairie, oak barrens, oak-pine barrens, and pine barrens.

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For a full list of references used to create this description, please refer to the natural community abstract for dry sand prairie.

Dry-mesic Prairie

Global/State Rank: G3/S1

Overview

Dry-mesic prairie is a native grassland community dominated by big bluestem (*Andropogon gerardii*), little bluestem (*Andropogon scoparius*), and Indian grass (*Sorghastrum nutans*). The community occurs on sandy loam or loamy sand on level to gently sloping sites of glacial outwash, coarse-textured end moraines, and glacial till plain. The community represents the stands of open grassland that occurred in association with historic oak openings throughout much of southern Lower Michigan. In previous versions of the natural community classification this community was called woodland prairie.

Landscape Context

Dry-mesic prairie occurs primarily on level to gently sloping sites of glacial outwash or coarse-textured end moraines. Historically, the majority of dry-mesic prairies occurred within oak openings in the Kalamazoo Interlobate Subsection and may have graded into mesic prairie and bur oak plains on level outwash plains such as the Battlecreek Outwash Plain. Today, the community is almost entirely restricted to railroad right-of-ways, which typically border agricultural fields.

Soils

Soils are typically strongly acid to circumneutral sandy loam or occasionally loamy sand with moderate water-retaining capacity.

Natural Processes

Fire played a critical role in creating and maintaining the open conditions of Michigan prairie and oak savanna ecosystems. Fire maintains species diversity by promoting seed germination, creating microsites for seedling establishment, and releasing and recycling important plant nutrients. In the absence of frequent fires, which suppress woody vegetation, Michigan's prairies and open oak ecosystems (e.g., oak openings, bur oak plains, oak barrens, and oak woodlands) are quickly colonized by trees and shrubs and convert to oak forests.

While occasional lightning strikes resulted in landscape-scale fires, Native Americans were the main source of ignition prior to European settlement. Native Americans intentionally set fires to clear brush, make land more passable, increase productivity of berry crops and agricultural fields, and improve hunting. The frequency and intensity of historical fires varied depending on the type and volume of fuel, topography, presence of natural firebreaks, and density of Native Americans. Carried by wind, landscape-scale fires moved across outwash plains and up slopes of end moraines and ground moraines, converting oak forests into dry-mesic prairies and oak openings.

Vegetation

Unfortunately, no detailed ecological study of dry-mesic prairie was completed in Michigan before the nearly total demise of the community. What information is available comes from written descriptions of the community by early European settlers and from studies of small prairie remnants in Michigan and Wisconsin. Dry-mesic prairie supports a dense to moderately dense growth of low- to medium-height herbaceous vegetation with very little bare ground. The community is dominated by big bluestem, little bluestem, and Indian grass, which may vary in

relative dominance. Species that reach their greatest abundance in dry-mesic prairie in Michigan include leadplant (*Amorpha canescens*), thimbleweed (*Anemone cylindrica*), butterfly weed (*Asclepias tuberosa*), smooth aster (*Aster laevis*), and daisy fleabane (*Erigeron strigosus*). Grubs of white oak (*Quercus alba*), black oak (*Q. velutina*), and bur oak (*Q. macrocarpa*), which were maintained in a shrub-like condition as a result of annual fires, were abundant in dry-mesic prairie, as were widely scattered, open grown adults of these same species, especially white oak. In addition to the species mentioned above, other common plants of Michigan dry-mesic prairie include Pennsylvania sedge (*Carex pennsylvanica*), bastard toadflax (*Comandra umbellata*), tall lettuce (*Lactuca canadensis*), round-headed bush clover (*Lespedeza capitata*), wild strawberry (*Fragaria virginiana*), wild bergamot (*Monarda fistulosa*), northern dewberry (*Rubus flagellaris*), black-eyed Susan (*Rudbeckia hirta*), old-field goldenrod (*Solidago nemoralis*), spiderwort (*Tradescantia ohimensis*), and pasture rose (*Rosa carolina*).

Noteworthy Animals

Ants, particularly the genus *Formica*, play an important role in mixing and aerating prairie soils as they continually build and abandon mounds, overturning large portions of soil in the process. Other important species contributing to soil mixing and aeration include moles, mice, striped skunks (*Mephitis mephitis*), and badgers (*Taxidea taxus*). Historically, large herbivores such as bison (*Bison bison*) likely significantly influenced plant species diversity in prairie and oak savanna ecosystems. Bison selectively forage on grasses and sedges, thereby reducing the dominance of graminoids and providing a competitive advantage to forb species. Additionally, bison wallowing and trampling promotes plant species diversity by creating microsites for seed germination and seedling establishment and reducing the dominance of robust perennials.

Rare Plants

Amorpha canescens (leadplant, state special concern)
Baptisia lactea (white false indigo, state special concern)
Carex inops ssp. *heliophila* (sun sedge, state special concern)
Cirsium hillii (Hill's thistle, state special concern)
Coreopsis palmata (prairie coreopsis, state threatened)
Echinacea purpurea (purple coneflower, presumed extirpated from Michigan)
Gentiana flavida (white gentian, state endangered)
Helianthus microcephalus (small wood sunflower, presumed extirpated from Michigan)
Houstonia caerulea (bluets, presumed extirpated from Michigan)
Onosmodium molle (marbleweed, presumed extirpated from Michigan)
Oxalis violacea (violet wood-sorrel, presumed extirpated from Michigan)
Panicum leibergii (Leiberg's panic grass, state threatened)
Pycnanthemum pilosum (hairy mountain mint, state threatened)
Rudbeckia subtomentosa (sweet coneflower, presumed extirpated from Michigan)
Scleria triglomerata (tall nut-rush, state special concern)
Silphium integrifolium (rosinweed, state threatened)
Viola pedatifida (prairie birdfoot violet, state threatened)

Rare Animals

Ammodramus henslowii (Henslow's sparrow, state endangered)
Ammodramus savannarum (grasshopper sparrow, state special concern)
Asio flammeus (short-eared owl, state special concern)
Asio otus (long-eared owl, state threatened)
Circus cyaneus (northern harrier, state special concern)
Clemmys guttata (spotted turtle, state threatened)
Clonophis kirtlandii (Kirtland's snake, state threatened)

Emydoidea blandingii (Blanding's turtle, state special concern)
Lanius ludovicianus migrans (migrant loggerhead shrike, state endangered)
Microtus ochrogaster (prairie vole, state endangered)
Oecanthus pini (pinetree cricket, federal/state endangered)
Pantherophis spiloides (gray ratsnake, state special concern)
Papaipema beeriana (blazing star borer, state special concern)
Prosapia ignipectus (red-legged spittlebug, state special concern)
Pygarctia spraguei (Sprague's pygarctia, state special concern)
Schinia indiana (phlox moth, state special concern)
Schinia lucens (leadplant flower moth, state endangered)
Sistrurus c. catenatus (eastern massasauga, federal candidate species and state special concern)
Speyeria idalia (regal fritillary, state endangered)
Spiza americana (dickcissel, state special concern)
Sturnella neglecta (western meadowlark, state special concern)
Terrapene c. carolina (eastern box turtle, state special concern)
Tyto alba (barn owl, state endangered)

Biodiversity Management Considerations

Priorities for conservation of dry-mesic prairie include identifying, protecting, and managing existing remnants where they occur. Several studies to identify prairie remnants in Michigan have been undertaken and most remnants are very small and/or occur as narrow strips adjacent to railroads and agricultural fields. The small size and poor landscape context of most remnant dry-mesic prairies make large-scale restoration of existing prairies nearly impossible. Restoration efforts for dry-mesic prairie should include establishing the community on appropriate sites within the former range of oak openings in southern Lower Michigan. Many suitable sites now support closed-canopy oak forest with understories and canopy trees of red maple. While restoring the matrix community to oak openings, land managers can also establish larger openings with species composition representative of dry-mesic prairie. Reintroducing fire on a frequent or annual basis, along with removing red maple and other mesophytic and invasive tree and shrub species within the former oak openings, will be important management steps in restoring dry-mesic prairie in southern Lower Michigan.

Restoring and managing dry-mesic prairie require frequent prescribed burning to protect and enhance plant species diversity, prevent encroachment of trees and tall shrubs, and control invasive species. Brush cutting accompanied by stump application of herbicide can also be an important component of prairie restoration. To reduce the impacts of management on fire-intolerant species it is important to consider a rotating schedule of prescribed burning in which adjacent management units are burned in alternate years. Alternating burn units provides refugia for fire-intolerant insect species that are then able to recolonize the burned areas. Avian species diversity can also be enhanced by managing large areas as a mosaic of burned and unburned patches. In addition, most restoration sites will require the reintroduction of appropriate native species and genotypes as plant populations at small, isolated prairie remnants may have suffered from reduced gene flow.

Monitoring and control efforts to detect and remove invasive species are critical to the long-term viability of dry-mesic prairie. Invasive species that threaten the diversity and community structure include glossy buckthorn (*Rhamnus frangula*), common buckthorn (*R. cathartica*), autumn olive (*Elaeagnus umbellata*), Eurasian honeysuckles (*Lonicera morrowii*, *L. japonica*, *L. maackii*, *L. sempervirens*, *L. tatarica*, *L. xbella*, and *L. xylosteum*), multiflora rose (*Rosa multiflora*), spotted knapweed (*Centaurea maculosa*), common St. John's-wort (*Hypericum perforatum*), ox-eye daisy (*Chrysanthemum leucanthemum*), hawkweeds (*Hieracium* spp.), hoary alyssum (*Berteroa*

incana), white sweet-clover (*Melilotus alba*), yellow sweet clover (*M. officinalis*), leafy spurge (*Euphorbia esula*), wild parsnip (*Pastinaca sativa*), bouncing bet (*Saponaria officinalis*), Canada bluegrass (*Poa compressa*), Kentucky bluegrass (*Poa pratensis*), smooth brome (*Bromus inermis*), and timothy (*Phleum pratense*).

Similar Natural Communities

Oak openings, dry sand prairie, hillside prairie, mesic sand prairie, oak barrens, bur oak plains, and mesic prairie.

Relevant Literature

- Albert, D.A. 1995. Regional landscape ecosystems of Michigan, Minnesota, and Wisconsin: A working map and classification. USDA, Forest Service, North Central Forest Experiment Station, St. Paul, MN.
- Chapman, K.A. 1984. An ecological investigation of native grassland in southern Lower Michigan. M.S. thesis, Western Michigan University, Kalamazoo, MI. 235 pp.
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- Thompson, P.W. 1970. The preservation of prairie stands in Michigan. Pp. 13-14 in *Proceedings of the Second Midwest Prairie Conference*, ed. J.H. Zimmerman. Madison, WI. 242 pp.
- Thompson, P.W. 1975. The floristic composition of prairie stands in southern Michigan. Pp. 317-331 in *Prairie: A multiple view*, ed. M.K. Wali. The University of North Dakota, Grand Fork, N.D. 433 pp.
- Thompson, P.W. 1983. Composition of prairie stands in southern Michigan and adjoining areas. Pp. 105-111 in *Proceedings of the Eighth North American Prairie Conference*, ed. R. Brewer. Western Michigan University, Kalamazoo, MI. 175 pp.
- Trager, J.C. 1990. Restored prairies colonized by native prairie ants (Missouri, Illinois). *Restoration and Management Notes* 8: 104-105.

For a full list of references used to create this description, please refer to the natural community abstract for dry-mesic prairie.

Mesic Sand Prairie

Global/State Rank: G2/S1

Overview

Mesic sand prairie is a native grassland community occurring on sandy loam, loamy sand, or sand soils on nearly level glacial outwash plains and lakeplains in both the northern and southern Lower Peninsula. Sites that support mesic sand prairie experience fluctuating water tables, with relatively high water tables occurring in the spring followed by drought conditions in late summer and fall. Thus, the community contains species from a broad range of moisture classes, but is dominated by species of upland affinity. Dominant grasses include little bluestem (*Andropogon scoparius*), big bluestem (*Andropogon gerardii*), and Indian grass (*Sorghastrum nutans*).

Landscape Context

Mesic sand prairie occurs in shallow depressions within glacial outwash plains and lakeplains, and on old, abandoned glacial lakebeds, stream channels, and river terraces. On these landforms, it can occur as a broad, expansive feature or form a narrow vegetation zone between fire-dependent uplands and open wetlands such as intermittent wetland or coastal plain marsh. Upland communities that border mesic sand prairie are typically fire-dependent savannas, prairies, and forests.

Soils

Soils are predominantly strongly acid to neutral sandy loam and occasionally loamy sand. The dry-mesic to mesic condition of the sandy soils is facilitated by a relatively high water table and, in some sites, by organic content within the sand matrix, which increases water-holding capacity. Mesic sand prairie experiences seasonal water table fluctuations, with the wettest conditions occurring in spring and driest periods in late summer and fall.

Natural Processes

Seasonal and annual water level fluctuations and sandy soils create conditions suitable for plant species representing a broad range of moisture tolerances, primarily species requiring mesic to dry conditions. Prior to European settlement in the early 1800s, fires of natural and anthropogenic origin limited encroachment by shrubs and trees. Fire helps maintain species diversity by facilitating seed germination, opening microsites for seedling establishment and growth of small species, and releasing important plant nutrients that bolster plant growth, flowering, and seed set.

Vegetation

Dominant grasses include little bluestem, big bluestem, and Indian grass. Pennsylvania sedge (*Carex pensylvanica*) is often important. Low areas transitional to wet-mesic prairie or wet-mesic sand prairie have increased importance of bluejoint grass (*Calamagrostis canadensis*), cordgrass (*Spartina pectinata*), sedges (*Carex* spp.), rushes (*Juncus* spp.), and bulrushes (*Scirpus* spp.). Common forbs include colic root (*Aletris farinosa*), thimbleweed (*Anemone cylindrica*), spreading dogbane (*Apocynum androsaemifolium*), arrow-leaved aster (*Aster sagittifolius*), tall coreopsis (*Coreopsis tripteris*), smooth scouring rush (*Equisetum laevigatum*), flowering spurge (*Euphorbia corollata*), wild strawberry (*Fragaria virginiana*), northern bedstraw (*Galium boreale*), tall sunflower (*Helianthus giganteus*), alum root (*Heuchera americana*), path rush (*Juncus tenuis*), false dandelion (*Krigia biflora*), prairie phlox (*Phlox pilosa*), old-field cinquefoil (*Potentilla simplex*), black-eyed Susan (*Rudbeckia hirta*), stiff goldenrod (*Solidago rigida*), Missouri ironweed (*Vernonia missurica*), and arrow-leaved violet (*Viola sagittata*). The

following shrubs and trees are occasional to common, especially in fire-suppressed occurrences: red maple (*Acer rubrum*), quaking aspen (*Populus tremuloides*), oaks (*Quercus* spp.), sumacs (*Rhus* spp.), pasture rose (*Rosa carolina*), raspberries (*Rubus* spp.), and sassafras (*Sassafras albidum*). Canada bluegrass (*Poa compressa*), an invasive species, is common in some sites.

Noteworthy Animals

Ants, particularly the genus *Formica*, play an important role in mixing and aerating prairie soils as they continually build and abandon mounds, overturning large portions of prairie soil in the process. Other important species contributing to soil mixing and aeration include moles, mice, skunks (*Mephitis mephitis*), and badgers (*Taxidea taxus*).

Rare Plants

Asclepias hirtella (tall green milkweed, state threatened)
Asclepias purpurascens (purple milkweed, state threatened)
Baptisia lactea (white false indigo, state special concern)
Carex tinctoria (sedge, state threatened)
Eryngium yuccifolium (rattlesnake-master, state threatened)
Helianthus mollis (downy sunflower, state threatened)
Lactuca floridana (woodland lettuce, state threatened)
Oxalis violacea (violet wood-sorrel, presumed extirpated from Michigan)
Sisyrinchium farwellii (Farwell's blue-eyed-grass, presumed extirpated from Michigan)
Sisyrinchium strictum (blue-eyed-grass, state special concern)
Sporobolus heterolepis (prairie dropseed, state special concern)
Strophostyles helvula (trailing wild bean, state special concern)
Trichostema dichotomum (bastard pennyroyal, state threatened)
Viola novae-angliae (New England violet, state threatened)

Rare Animals

Ammodramus henslowii (Henslow's sparrow, state endangered)
Ammodramus savannarum (grasshopper sparrow, state special concern)
Asio flammeus (short-eared owl, state endangered)
Atrytonopsis hianna (dusted skipper, state special concern)
Chlosyne gorgone carlota (Gorgone checkerspot, state special concern)
Chondestes grammacus (lark sparrow, presumed extirpated from Michigan)
Clemmys guttata (spotted turtle, state threatened)
Emydoidea blandingii (Blanding's turtle, state special concern)
Flexamia reflexus (leafhopper, state special concern)
Lanius ludovicianus migrans (migrant loggerhead shrike, state endangered)
Microtus ochrogaster (prairie vole, state endangered)
Pantherophis spiloides (gray ratsnake, state special concern)
Phyciodes batesii (tawny crescent, state special concern)
Pygarcia spraguei (Sprague's pygarcia, state special concern)
Schinia indiana (phlox moth, state endangered)
Sistrurus c. catenatus (eastern massasauga, federal candidate species and state special concern)
Spartiniphaga inops (spartina moth, state special concern)
Speyeria idalia (regal fritillary, state endangered)
Spiza americana (dickcissel, state special concern)
Sturnella neglecta (western meadowlark, state special concern)
Terrapene c. carolina (eastern box turtle, state special concern)

Biodiversity Management Considerations

Priorities for conservation of mesic sand prairie include identifying, protecting, and managing existing remnants where they occur. The primary threat to mesic sand prairie is fire suppression. Fire suppression promotes shrub and tree invasion, which significantly reduces graminoid and forb cover. Prescribed fire can be employed to restrict encroaching trees and shrubs, reduce litter build-up, and promote seed bank expression. Sites impacted by severe encroachment of tall shrubs and trees require an initial step of cutting and herbiciding woody stems. Selective use of herbicide can also be used to control invasive species not reduced or eliminated by application of prescribed fire. Severely degraded sites may require reintroduction of appropriate species and, where feasible, local genotypes.

Monitoring and control efforts to detect and remove invasive species are critical to the long-term viability of mesic sand prairie. Invasive species that threaten the diversity and community structure include glossy buckthorn (*Rhamnus frangula*), common buckthorn (*Rhamnus cathartica*), autumn olive (*Elaeagnus umbellata*), Eurasian honeysuckles (*Lonicera morrowii*, *L. japonica*, *L. maackii*, *L. sempervirens*, *L. tatarica*, *L. xbella*, and *L. xylosteum*), multiflora rose (*Rosa multiflora*), spotted knapweed (*Centaurea maculosa*), common St. John's-wort (*Hypericum perforatum*), ox-eye daisy (*Chrysanthemum leucanthemum*), hawkweeds (*Hieracium* spp.), white sweet-clover (*Melilotus alba*), yellow sweet clover (*M. officinalis*), Japanese knotweed (*Polygonum cuspidatum*), leafy spurge (*Euphorbia esula*), wild parsnip (*Pastinaca sativa*), bouncing bet (*Saponaria officinalis*), hoary alyssum (*Berteroa incana*), Canada bluegrass, Kentucky bluegrass (*Poa pratensis*), smooth brome (*Bromus inermis*), and timothy (*Phleum pratense*).

Variation

Sites range from mesic to dry-mesic, with dry-mesic sites lacking species of wetland affinity. Prairie plant species diversity is generally higher in occurrences located in far southwestern Michigan than in those located further east or north, likely due to their closer proximity to the central range of prairie in North America.

Similar Natural Communities

Wet-mesic sand prairie, dry-mesic prairie, dry sand prairie, mesic prairie, and lakeplain wet-mesic prairie.

Relevant Literature

- Chapman, K.A. 1984. An ecological investigation of native grassland in southern Lower Michigan. M.A. thesis, Western Michigan University, Kalamazoo, MI. 235 pp.
- Faber-Langendoen, D., and P.F. Maycock. 1992. A vegetation analysis of tallgrass prairie in southern Ontario. Pp. 17-32 in Proceedings of the Thirteenth North American Prairie Conference: Spirit of the land, our prairie legacy, ed. R.G. Wickett, P.D. Lewis, A. Woodliffe, and P. Pratt. Department of Parks and Recreation, Windsor, Ontario, Canada. 262 pp.
- Kost, M.A. 2005. Natural community abstract for mesic sand prairie. Michigan Natural Features Inventory, Lansing, MI. 11 pp.
- NatureServe. 2006. NatureServe Explorer: An online encyclopedia of life [Web application]. Version 6.1. NatureServe, Arlington, VA. Available <http://www.natureserve.org/explorer>. (Accessed: January 12, 2007.)

For a full list of references used to create this description, please refer to the natural community abstract for mesic sand prairie.

Mesic Prairie

Global/State Rank: G2/S1

Overview

Mesic prairie is a native grassland community dominated by big bluestem (*Andropogon gerardii*), little bluestem (*Andropogon scoparius*), and Indian grass (*Sorghastrum nutans*). It occurs on loam, sandy loam or silt loam soils on level or slightly undulating glacial outwash. Historically, mesic prairie dominated large portions of the Midwest ranging from Iowa and southern Minnesota east into southwestern Michigan and northern Ohio. In Michigan, mesic prairie occurred historically in Kalamazoo, St. Joseph, Cass, Branch, Calhoun, Berrien, and Van Buren Counties.

Landscape Context

In Michigan, mesic prairie occurs almost exclusively on glacial outwash on nearly level to slightly undulating sites. Historically, the majority of mesic prairies occurred on the Battlecreek Outwash Plain Sub-subsection within the Kalamazoo Interlobate Subsection. This level outwash plain is the northernmost portion of the “Prairie Peninsula.” In the 1800s, mesic prairie in Michigan frequently bordered beech-maple forest (mesic southern forest) or graded into bur oak plains, which both occupied level outwash plains and grew on similarly rich soils. Where level outwash plains met end moraines and ground moraines with sandy, drier soils, mesic prairie gave way to dry-mesic prairie and oak openings, or oak woodlands (dry-mesic southern forest). Presently, the community is restricted to railroad right-of-ways, cemeteries, and other small remnants that typically border agricultural fields.

Soils

Soils supporting mesic prairie are very strongly acid to mildly alkaline loam or sandy loam and occasionally silt loam with moderate water-retaining capacity. The soil profile often contains a B horizon dominated by clay. Mesic prairies in Michigan occur on both mollisols, which are considered true prairie soils, and udic alfisols, which cover much of southern Lower Michigan and are considered gray to brown forest soils.

Natural Processes

Historically, fire played a critical role in maintaining the open conditions of Michigan prairie and oak savanna ecosystems. In addition to suppressing the growth of woody vegetation, fire maintains species diversity by facilitating seed germination, creating microsites for seedling establishment, and releasing and recycling important plant nutrients.

While occasional lightning strikes resulted in landscape-scale fires, Native Americans were the main source of ignition prior to European settlement. Native Americans intentionally set fires to clear brush, make land more passable, increase productivity of berry crops and agricultural fields, and improve hunting. The frequency and intensity of historical fires varied depending on the type and volume of fuel, topography, presence of natural firebreaks, and density of Native Americans. The rich soils of mesic prairie promoted very high volumes of fine fuels (e.g., grasses), which enabled fire to rapidly spread throughout the community. On the level outwash plains of southwestern Lower Michigan, annual, wind-swept fires once spread easily through the mesic prairies and bur oak plains. Carried by wind, these fires moved across the outwash plains and up slopes of end moraines and ground moraines, converting oak forests into prairies and oak openings.

Vegetation

Unfortunately, no detailed ecological study of mesic prairie was completed in Michigan before the nearly total demise of the community. What information is available comes from written descriptions by early European settlers and studies of small prairie remnants in Michigan and Wisconsin. Mesic prairies are graminoid-dominated, forb-rich herbaceous communities. The rich loamy soils support a dense to moderately dense growth of medium to tall vegetation. The community is dominated by big bluestem, little bluestem, and Indian grass, which vary in relative dominance. Cordgrass (*Spartina pectinata*) is occasionally subdominant. Several other grasses, including porcupine grass (*Stipa spartea*), prairie dropseed (*Sporobolus heterolepis*, state threatened), Leiberg's panic grass (*Panicum leibergii*, state threatened), and switch grass (*P. virgatum*), are important components of mesic prairie elsewhere in the Midwest and are likely to have been important components of mesic prairie in Michigan historically. Characteristic plants of Michigan's mesic prairies include New Jersey tea (*Ceanothus americanus*), tall coreopsis (*Coreopsis tripteris*), American hazelnut (*Corylus americana*), northern bedstraw (*Galium boreale*), tall lettuce (*Lactuca canadensis*), pasture rose (*Rosa carolina*), prairie willow (*Salix humilis*), stiff goldenrod (*Solidago rigida*), purple meadow rue (*Thalictrum dasycarpum*), Culver's root (*Veronicastrum virginicum*), and bur oak (*Quercus macrocarpa*).

Noteworthy Animals

Ants, particularly the genus *Formica*, play an important role in mixing and aerating prairie soils as they continually build and abandon mounds, overturning large portions of prairie soil in the process. Other important species contributing to soil mixing and aeration include moles, mice, skunks (*Mephitis mephitis*), and badgers (*Taxidea taxus*). Historically, large herbivores such as bison (*Bison bison*) likely also significantly influenced plant species diversity in prairie and oak savanna ecosystems. Bison selectively forage on grasses and sedges, thereby reducing the dominance of graminoids and providing a competitive advantage to forb species. Additionally, wallowing and trampling by bison helps promote plant species diversity by creating microsites for seed germination and seedling establishment and reducing the dominance of robust perennials.

Rare Plants

Amorpha canescens (leadplant, state special concern)
Baptisia lactea (white false indigo, state special concern)
Baptisia leucophaea (cream wild indigo, state endangered)
Coreopsis palmata (prairie coreopsis, state threatened)
Dodecatheon meadia (shooting star, state endangered)
Echinacea purpurea (purple coneflower, presumed extirpated from Michigan)
Eryngium yuccifolium (rattlesnake-master, state threatened)
Gentiana flavida (white gentian, state endangered)
Houstonia caerulea (bluets, presumed extirpated from Michigan)
Oxalis violacea (violet wood-sorrel, presumed extirpated from Michigan)
Panicum leibergii (Leiberg's panic grass, state threatened)
Polygala incarnata (pink milkwort, presumed extirpated from Michigan)
Rudbeckia subtomentosa (sweet coneflower, presumed extirpated from Michigan)
Silphium integrifolium (rosinweed, state threatened)
Silphium laciniatum (compass-plant, state threatened)
Sisyrinchium strictum (blue-eyed-grass, state special concern)
Spiranthes ovalis (lesser ladies'-tresses, state threatened)
Sporobolus heterolepis (prairie dropseed, state threatened)
Viola pedatifida (prairie birdfoot violet, state threatened)

Rare Animals

Ammodramus henslowii (Henslow's sparrow, state endangered)
Ammodramus savannarum (grasshopper sparrow, state special concern)
Asio flammeus (short-eared owl, state special concern)
Asio otus (long-eared owl, state threatened)
Circus cyaneus (northern harrier, state special concern)
Clemmys guttata (spotted turtle, state threatened)
Clonophis kirtlandii (Kirtland's snake, state threatened)
Emydoidea blandingii (Blanding's turtle, state special concern)
Flexamia delongi (leafhopper, state special concern)
Flexamia reflexus (leafhopper, state special concern)
Lanius ludovicianus migrans (migrant loggerhead shrike, state endangered)
Microtus ochrogaster (prairie vole, state endangered)
Pantherophis spiloides (gray ratsnake, state special concern)
Papaipema beeriana (blazing star borer, state special concern)
Papaipema sciata (Culver's root borer, state special concern)
Papaipema silphii (silphium borer, state threatened)
Prosapia ignipectus (red-legged spittlebug, state special concern)
Pygarcia spraguei (Sprague's pygarcia, state special concern)
Schinia lucens (leadplant flower moth, state endangered)
Sistrurus c. catenatus (eastern massasauga, federal candidate species and state special concern)
Spartiniphaga inops (spartina moth, state special concern)
Spiza americana (dickcissel, state special concern)
Sturnella neglecta (western meadowlark, state special concern)
Terrapene c. carolina (eastern box turtle, state special concern)
Tyto alba (barn owl, state endangered)

Biodiversity Management Considerations

Conservation priorities for mesic prairies include identifying, protecting, and managing existing remnants where they occur. Managing mesic prairie requires frequent prescribed burning to protect and enhance plant species diversity, prevent encroachment of trees and tall shrubs, and control non-native invasive species. In addition to prescribed fire, brush cutting accompanied by stump application of herbicide, can be an important component of prairie restoration. To reduce the impacts of management on fire-sensitive species it is important to consider a rotating schedule of prescribed burning in which adjacent management units are burned in alternate years. Alternating burn units provides refugia for fire-intolerant insect species that are then able to recolonize burned areas. Avian species diversity is also thought to be enhanced by managing large areas as a mosaic of burned and unburned patches.

In addition to reestablishing ecological processes such as fire, most restoration sites will require the reintroduction of appropriate native species and genotypes through seeding or seedling transplants. Small, isolated prairie remnants may harbor plant populations that have suffered from reduced gene flow. Restoration efforts at isolated prairie remnants should consider introducing seeds collected from nearby stocks to augment and maintain genetic diversity of remnant plant populations.

Monitoring and control efforts to detect and remove invasive species are critical to the long-term viability of mesic prairie. Invasive species that threaten the diversity and community structure include glossy buckthorn (*Rhamnus frangula*), common buckthorn (*Rhamnus cathartica*), autumn

olive (*Elaeagnus umbellata*), Eurasian honeysuckles (*Lonicera morrowii*, *L. japonica*, *L. maackii*, *L. sempervirens*, *L. tatarica*, *L. xbella*, and *L. xylosteum*), multiflora rose (*Rosa multiflora*), common St. John's-wort (*Hypericum perforatum*), ox-eye daisy (*Chrysanthemum leucanthemum*), hawkweeds (*Hieracium* spp.), white sweet-clover (*Melilotus alba*), yellow sweet clover (*M. officinalis*), Japanese knotweed (*Polygonum cuspidatum*), leafy spurge (*Euphorbia esula*), wild parsnip (*Pastinaca sativa*), bouncing bet (*Saponaria officinalis*), Canada bluegrass (*Poa compressa*), Kentucky bluegrass (*Poa pratensis*), smooth brome (*Bromus inermis*), quack grass (*Agropyron repens*), and timothy (*Phleum pratense*).

Variation

Prairie plant species diversity is generally higher in occurrences located in far southwestern Michigan than in those located further east or north, likely due to their closer proximity to the central range of prairie in North America.

Similar Natural Communities

Dry-mesic prairie, bur oak plains, oak openings, and mesic sand prairie.

Relevant Literature

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For a full list of references used to create this description, please refer to the natural community abstract for mesic prairie.

Hillside Prairie

Global/State Rank: G3/S1

Overview

Hillside prairie is a grassland or savanna community that occurs on moderate to steep exposed slopes and crests of hills associated with river valleys, streams, or kettle lakes, surrounded by oak forest or oak savanna. This natural community is almost always found on south- to west-facing slopes, where exposure to sunlight is highest. Soils are typically strongly acid to neutral loamy sand or sandy loam, and often mixed with gravel. Hillside prairie is notable for supporting several state-listed plant species largely restricted to this community type.

Landscape Context

Hillside prairie occurs on steep slopes and crests of hills associated with river valleys, streams, or kettle lakes, surrounded by oak forest (dry southern forest, dry-mesic southern forest, or dry-mesic northern forest) or oak savanna (oak barrens or oak openings). This community almost always occupies south- to west-facing slopes, where exposure to sunlight is highest. It is found primarily in southern Lower Michigan, where occurrences are concentrated in Kent, Kalamazoo, and Jackson Counties. One occurrence is known from the western Upper Peninsula. Due to the specific combination of slope, aspect, and soil type, hillside prairie occurrences are local and of very small size.

Soils

Soils are well-drained, sandy loam to loamy sand and can range from strongly acid to neutral. Gravel is often present at or near the surface. One occurrence of hillside prairie is associated with exposed pre-glacial fluvial deposits of shale and conglomerate rocks.

Natural Processes

Open conditions of hillside prairie are maintained by fire, droughty soils, steep slopes, and soil erosion. Fire likely played a significant role in maintaining open conditions prior to European settlement based on the dominance of oaks in the surrounding landscape and presence of trails that led through or passed by several hillside prairie sites, suggesting their use as Native American encampments. In addition to preserving open conditions, fire helps maintain species diversity by facilitating seed germination, opening microsites for seedling establishment and growth of small species, and releasing important plant nutrients that bolster plant growth, flowering, and seed set.

Several factors contribute to the droughty conditions of hillside prairie. Steep slopes and sandy soils facilitate rapid drainage. Exposed slopes of southerly to westerly aspect are exposed to high amounts of incident sunlight, which increases soil temperatures and the rate of evapotranspiration at the ground level. Xeric conditions on exposed hillsides and hilltops are further enhanced by the prevailing southwesterly winds, which increase water loss from plants and soils.

Due to the steep slopes of hillside prairie, soil erosion and slumping are common. These processes contribute to maintaining open conditions and species diversity. Seed germination and seedling establishment of several small species may be aided by soil erosion and associated slumping as the bare soil patches provide suitable habitat for low-growing species that would otherwise be eliminated by competition from taller, more robust herbaceous plants.

Vegetation

Prior to European settlement and subsequent fire suppression, the canopy layer was likely absent to sparse, with scattered open-grown trees of black oak (*Quercus velutina*), white oak (*Q. alba*), pignut hickory (*Carya glabra*), and white pine (*Pinus strobus*). Currently, many remnants have locally dense canopies of the same species, in addition to the presence of mesophytic tree species that thrive in low-light conditions. Cover of the subcanopy and shrub layers has also increased in many hillside prairies due to a lack of fire. Characteristic species of the overstory, understory, and shrub layers include quaking aspen (*Populus tremuloides*), sassafras (*Sassafras albidum*), red cedar (*Juniperus virginiana*), ironwood (*Ostrya virginiana*), witch-hazel (*Hamamelis virginiana*), juneberry (*Amelanchier arborea*), staghorn sumac (*Rhus typhina*), and American hazelnut (*Corylus americanus*). Remnant prairie openings, often very limited in extent, are typically dominated by little bluestem (*Andropogon scoparius*), big bluestem (*Andropogon gerardii*), porcupine grass (*Stipa spartea*), and Pennsylvania sedge (*Carex pensylvanica*), with Indian grass (*Sorghastrum nutans*) occasionally important in more mesic microhabitats on middle and lower slopes. The invasive grasses Canada bluegrass (*Poa compressa*) and Kentucky bluegrass (*P. pratensis*) are common in most sites. Other commonly occurring ground flora include thimbleweed (*Anemone cylindrica*), milkweeds (*Asclepias* spp.), asters (*Aster* spp.), harebell (*Campanula rotundifolia*), New Jersey tea (*Ceanothus americanus*), bastard toadflax (*Comandra umbellata*), flowering spurge (*Euphorbia corollata*), northern bedstraw (*Galium boreale*), round-leaved hepatica (*Hepatica americana*), alum root (*Heuchera* spp.), cylindrical blazing star (*Liatris cylindracea*), northern blazing star (*L. scariosa*), hoary puccoon (*Lithospermum canescens*), hairy beard-tongue (*Penstemon hirsutus*), prairie ragwort (*Senecio plattensis*), false Solomon's seal (*Smilacina racemosa*), goldenrods (*Solidago* spp.), birdfoot violet (*Viola pedata*), and summer grape (*Vitis aestivalis*). In Michigan, several rare plant species are nearly restricted to hillside prairie, including kitten-tails (*Besseyia bullii*, state endangered), side-oats grama grass (*Bouteloua curtipendula*, state endangered), and prairie golden alexanders (*Zizia aptera*, state threatened); their close affinity to hillside prairies allows them to serve as potential indicators for this community.

Noteworthy Animals

Hillside prairies and the surrounding oak opening habitat once supported a rich diversity of invertebrates including numerous species of butterflies, skippers, grasshoppers, and locusts. Mound-building ants mix and aerate the soil.

Rare Plants

Aristolochia serpentaria (Virginia snakeroot, state threatened)
Besseyia bullii (kitten-tails, state endangered)
Bouteloua curtipendula (side-oats grama grass, state endangered)
Draba reptans (creeping whitlow-grass, state threatened)
Eragrostis pilosa (small love grass, state special concern)
Kuhnia eupatorioides (false boneset, state special concern)
Panicum leibergii (Leiberg's panic grass, state threatened)
Ranunculus rhomboideus (prairie buttercup, state threatened)
Ruellia humilis (hairy ruellia, state threatened)
Scutellaria parvula (small skullcap, state threatened)
Zizia aptera (prairie golden alexanders, state threatened)

Rare Animals

Ammodramus henslowii (Henslow's sparrow, state endangered)
Ammodramus savannarum (grasshopper sparrow, state special concern)
Chlosyne gorgone carlota (Gorgone checkerspot, state special concern)

Erynnis p. persius (Persius duskywing, state threatened)
Flexamia delongi (leafhopper, state special concern)
Lepyronia gibbosa (Great Plains spittlebug, state special concern)
Speyeria idalia (regal fritillary, state endangered)
Sturnella neglecta (eastern meadowlark, state special concern)

Biodiversity Management Considerations

Conservation priorities for hillside prairies include identifying, protecting, and managing existing remnants where they occur. Fire suppression has resulted in conversion of many hillside prairies to closed-canopy forests, and continues to threaten existing sites. Open conditions can be restored through the use of prescribed fire. The initial step of cutting and herbiciding shrubs and trees may be necessary in overgrown sites. The sand and gravel substrate on steep slopes is prone to erosion, so care must be taken to prevent excessive foot traffic and soil disturbance. Invasive species can be controlled with fire, cutting, and herbicide application. Because several rare plants are nearly restricted to this habitat in Michigan, land stewards should take precautions to avoid direct impacts to these species from herbicide or excessive soil disturbance.

Much of our current knowledge of hillside prairie is based on studies of kitten-tails populations in Michigan, Indiana, Illinois, Wisconsin, and Minnesota. Current and historic locations for kitten-tails, side-oats grama, and other indicator species may serve as a guide to the locations of additional, potentially restorable former hillside prairies. Predictive GIS-based models that utilize landscape characteristics associated with the community may also be helpful in finding restorable sites.

Soil erosion, gravel mining, road construction, dumping, and invasive species all act as threats to the viability of hillside prairie. Invasive species that threaten the diversity and community structure of hillside prairie include spotted knapweed (*Centaurea maculosa*), common St. John's-wort (*Hypericum perforatum*), autumn olive (*Elaeagnus umbellata*), multiflora rose (*Rosa multiflora*), common buckthorn (*Rhamnus cathartica*), Eurasian honeysuckles (*Lonicera maackii*, *L. morrowii*, *L. tatarica*, and *L. xbella.*), and black locust (*Robinia pseudoacacia*). Other non-native plants, such as Canada bluegrass (*Poa compressa*), Kentucky bluegrass (*Poa pratensis*), sheep sorrel (*Rumex acetosella*), and hawkweeds (*Hieracium aurantiacum*), can be ubiquitous within hillside prairie remnants, yet their impacts on overall species composition and diversity have not been studied.

The landscape context of hillside prairies on steep, often scenic bluffs overlooking permanent bodies of water has led to the destruction of many remnants due to residential construction.

Variation

Middle and lower slopes may support mesic and wet-mesic conditions, respectively. White pine is an important canopy constituent in some occurrences.

Similar Natural Communities

Steep slope, south- to west-aspect, and plant species indicators differentiate hillside prairie from other similar prairie, savanna, and oak-dominated communities such as dry sand prairie, mesic sand prairie, dry-mesic prairie, mesic prairie, oak barrens, oak-pine barrens, oak openings, dry southern forest, and dry-mesic southern forest.

Relevant Literature

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SAVANNA COMMUNITIES

Pine Barrens

Global/State Rank: G3/S2

Overview

Pine barrens is a coniferous, fire-dependent savanna of scattered and clumped trees located north of the climatic tension zone in the northern Lower and Upper Peninsulas. The community occurs on level sandy outwash plains and sandy glacial lakeplains. The droughty sand soils are very strongly to strongly acid, with very poor water-retaining capacity. The community is dominated by jack pine (*Pinus banksiana*), with northern pin oak (*Quercus ellipsoidalis*) as a frequent canopy associate. Frequent fires, drought, and growing-season frosts maintain the open canopy conditions.

Landscape Context

Pine barrens typically occurs on level to gently sloping sandy outwash plains and sandy glacial lakeplains. The community occasionally occurs on sandy riverine terraces and moderate to steeply sloping ice-contact landforms that are located adjacent to broad outwash plains or lakeplains. The level topography and absence of natural fire breaks facilitate the spread of wildfire, which advances rapidly up adjacent moraines and ice-contact features. Where pine barrens occurs on pitted outwash and rolling topography, cold air collects in the depressions and forms frost pockets. Historically, pine barrens, dry sand prairie, and dry northern forest often occurred as a shifting mosaic, with species composition and community structure varying with fire frequency and fire intensity.

Soils

The soil is primarily excessively drained, very strongly to strongly acid sand, and relatively infertile. Thin bands of finer textured soil (loamy sand to sandy clay loam) are often present near moraines or ice-contact landforms. Such fine banding improves soil-water availability, resulting in more rapid tree growth and a faster rate of succession to forest.

Natural Processes

Frequent wildfire, in concert with drought, growing-season frosts, and low-nutrient soils, maintain open conditions in pine barrens. Fire allows the serotinous cones of jack pine to open and thereby facilitates seed dispersal. Fire is also essential in jack pine regeneration because it prepares the seedbed by exposing bare mineral soil, reducing competition from grasses, sedges, herbs, and woody vegetation, and increasing soil nutrient levels.

Vegetation

Jack pine typically dominates the open overstory. Red pine (*Pinus resinosa*) is often present, and widely scattered white pine (*P. strobus*) trees may also occur. Both red pine and white pine can form a sparse supercanopy above the scattered groves of jack pine. Northern pin oak, black cherry (*Prunus serotina*), and aspens (*Populus* spp.) are often found as stunted or young trees. Ground cover vegetation is characterized by a well developed, short shrub layer and numerous graminoid species. Low sweet blueberry (*Vaccinium angustifolium*), sweetfern (*Comptonia peregrina*), sand cherry (*Prunus pumila*), prairie willow (*Salix humilis*), and hazelnuts (*Corylus* spp.) make up most of the shrub layer when present. Poverty grass (*Danthonia spicata*), little

bluestem (*Andropogon scoparius*), and Pennsylvania sedge (*Carex pensylvanica*) are dominant herbaceous species across the range of this community. Other characteristic herbaceous species include big bluestem (*Andropogon gerardii*), hair grass (*Deschampsia flexuosa*), birdfoot violet (*Viola pedata*), prairie heart-leaved aster (*Aster oolentangiensis*), June grass (*Koeleria macrantha*), rough blazing star (*Liatris aspera*), prairie cinquefoil (*Potentilla arguta*), and porcupine grass (*Stipa spartea*). Bracken fern (*Pteridium aquilinum*) and reindeer lichen (*Cladina* spp.) are usually abundant.

Noteworthy Animals

Pine barrens and surrounding dry sand prairie habitat support a rich diversity of invertebrates including numerous species of butterflies, skippers, grasshoppers, and locusts. Pine barrens are essential to the survival of the Kirtland's warbler (*Dendroica kirtlandii*, federal/state endangered), an endangered songbird that breeds almost exclusively in the pine barrens of northern Lower Michigan.

Rare Plants

Agoseris glauca (pale agoseris, state threatened)
Cirsium hillii (Hill's thistle, state special concern)
Festuca scabrella (rough fescue, state threatened)
Oryzopsis canadensis (Canada rice-grass, state threatened)
Prunus alleghaniensis var. *davisii* (Alleghany plum, state special concern)

Rare Animals

Ammodramus savannarum (grasshopper sparrow, state special concern)
Appalachia arcana (secretive locust, state special concern)
Atrytonopsis hianna (dusted skipper, state special concern)
Dendroica discolor (prairie warbler, state endangered)
Dendroica kirtlandii (Kirtland's warbler, federal/state endangered)
Erynnis p. persius (Persius duskywing, state threatened)
Hesperia ottoe (ottoe skipper, state threatened)
Incisalia henrici (Henry's elfin, state threatened)
Incisalia irus (frosted elfin, state threatened)
Lepyronia gibbosa (Great Plains spittlebug, state special concern)
Lycaeides melissa samuelis (Karner blue, federal endangered and state threatened)
Prosapia ignipectus (red-legged spittlebug, state special concern)
Pygarcia spraguei (Sprague's pygarcia, state special concern)
Pyrgus centaureae wyandot (grizzled skipper, state special concern)
Terrapene c. carolina (eastern box turtle, state special concern)
Tympanuchus phasianellus (sharp-tailed grouse, state special concern)

Biodiversity Management Considerations

Fire is the single most significant factor in preserving the pine barrens landscape. Where remnants of pine barrens persist, the use of prescribed fire is an imperative management tool for maintaining an open canopy, promoting high levels of grass and forb diversity, deterring the encroachment of woody vegetation and invasive plants, and limiting the success of overstory dominants. When feasible, prescribed fire management for pine barrens should encompass other adjacent fire-dependent upland and wetland communities such as dry sand prairie, dry northern forest, dry-mesic northern forest, bog, poor fen, intermittent wetland, northern fen, and northern wet meadow. Where rare animal species are a management concern, burning strategies should allow for ample refugia to facilitate effective post-burn recolonization. Degraded barrens that

have been long deprived of fire and have converted to closed-canopy forest or woodland may require mechanical thinning or girdling prior to implementation of prescribed fire. Destructive timber exploitation of pines (1890s) and oaks (1920s) combined with post-logging slash fires likely destroyed or degraded many pine barrens. In addition, fire suppression policies instituted in the 1920s resulted in the succession of many open pine barrens to closed-canopy forests dominated by jack pine. Many sites formerly occupied by pine barrens were also converted to pine plantations. The fragments of pine barrens that remain often lack the full complement of conifers; scattered red pine and white pine, which create a supercanopy, were widely harvested. In addition to simplified overstory structure, these communities are often depauperate in floristic diversity as the result of fire suppression, livestock grazing, off-road-vehicle activity, and the subsequent invasion of non-native species.

Monitoring and control efforts to detect and remove invasive species before they become widespread are critical to the long-term viability of pine barrens. By outcompeting native species, invasives alter vegetation structure, reduce species diversity, and disrupt ecological processes. The following invasive species can be significant components of the herbaceous layer of degraded pine barrens: spotted knapweed (*Centaurea maculosa*), hawkweeds (*Hieracium* spp.), Canada bluegrass (*Poa compressa*), Kentucky bluegrass (*P. pratensis*), and sheep sorrel (*Rumex acetosella*). These widespread invasive species likely outcompete many native forb seedlings for nutrients, water, and space, and thereby, along with lack of fire, perpetuate low levels of native forb abundance within degraded pine barren remnants. Several additional invasive species that have potential to reduce diversity and alter community structure in the future include common St. John's-wort (*Hypericum perforatum*), autumn olive (*Elaeagnus umbellata*), common buckthorn (*Rhamnus cathartica*), and potentially, Eurasian honeysuckles (*Lonicera maackii*, *L. morrowii*, *L. tatarica*, and *L. xbella*).

Variation

Red pine and white pine were occasionally common canopy associates. Tree growth and rate of succession is lower in pine barrens found in cold, low-elevation landforms of the interior of Michigan than on lakeplains with lake-moderated climates or high-elevation landforms with better soils and more moderate climates.

Similar Natural Communities

Dry sand prairie, dry northern forest, Great Lakes barrens, oak barrens, and oak-pine barrens.

Relevant Literature

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For a full list of references used to create this description, please refer to the natural community abstract for pine barrens.

Oak-Pine Barrens

Global/State Rank: G3/S2

Overview

Oak-pine barrens is a fire-dependent, savanna community dominated by oaks and pines, having between 5 and 60% canopy cover, with or without a shrub layer. The predominantly graminoid ground layer contains plant species associated with both prairie and forest. The community occurs on a variety of landforms on droughty, infertile sand or loamy sands occasionally within southern Lower Michigan but mostly north of the climatic tension zone in the northern Lower and Upper Peninsulas.

Landscape Context

Oak-pine barrens occur on nearly level to slightly undulating ground in well-drained sandy glacial outwash, sandy glacial lakeplains, and less often on sandy areas in coarse-textured moraines. The community occurs in the driest landscape positions, such as ridge tops, steep slopes, south- to west-facing slopes, and flat sandplains. Oak-pine barrens typically grade into dry sand prairie on one edge and dry forest on the other. Wetlands occurring within depressions in areas of oak-pine barrens are usually open and may include coastal plain marsh, intermittent wetland, bog, poor fen, wet meadow, and northern fen.

Soils

Soils of oak-pine barrens are typically infertile, excessively well-drained sand or loamy sand with medium to slightly acid pH and low water-retaining capacity. Soils range from coarse-textured loam sands on moraines to very fine-textured sands on lakeplains. The soils contain little organic matter and are droughty.

Natural Processes

Oak-pine barrens likely originated when prairie fires spread into surrounding closed oak and pine forest with enough intensity to create open barrens. Repeated low-intensity fires working in concert with drought, frost, and windthrow maintained barrens ecosystems. Fires prevented canopy closure and the dominance of woody vegetation. Fires in oak-pine barrens and prairies occur during the spring, late summer, and fall. Flammability peaks bimodally, in the spring before grass and forb growth resumes and in the late summer and autumn after the above-ground biomass dies. Infrequent, high-intensity fires kill mature oaks and pines and produce barrens covered by abundant scrubby oak sprouts (i.e., oak grubs). In addition to fire, frequent growing-season frosts prevent maturation of oak grubs. Park-like barrens with widely spaced trees and an open grass understory are maintained by frequent, low-intensity fires that occur often enough to restrict maturation of oak grubs.

Numerous biotic factors influence the patterning of vegetation of oak-pine barrens. In addition to widely distributed overstory trees, barrens are characterized by scattered ant mounds. Mound-building ants play a crucial role in soil development of prairies and barrens; ants mix and aerate the soil as they build tunnels and bring soil particles and nutrients to the topsoil from lower soil horizons. Herbivores can limit woody establishment and growth. With their flammable properties, grasses and forbs help maintain the annual fire regime. Open canopy conditions are also preserved by the development of a dense herbaceous litter, which limits tree seedling establishment. Overstory trees influence vegetative composition by affecting the distribution of nutrients, light, and moisture.

Vegetation

The canopy layer generally varies from 5 to 60% cover and is dominated or codominated by the following trees: white oak (*Quercus alba*), black oak (*Q. velutina*), northern pin oak (*Q. ellipsoidalis*), bur oak (*Q. macrocarpa*), white pine (*Pinus strobus*), red pine (*P. resinosa*), and jack pine (*P. banksiana*). These pine and oak species are also prevalent in the subcanopy as multi-stemmed shrubs of stump-sprout origin, especially where fire intensity is high. Additional tree species found in the overstory and subcanopy include red maple (*Acer rubrum*), black cherry (*Prunus serotina*), big-toothed aspen (*Populus grandidentata*), and quaking aspen (*P. tremuloides*). Characteristic shrubs include the following: serviceberry (*Amelanchier* spp.), bearberry (*Arctostaphylos uva-ursi*), New Jersey tea (*Ceanothus americanus*), sweetfern (*Comptonia peregrina*), alternate-leaved dogwood (*Cornus alternifolia*), flowering dogwood (*C. florida*), American hazelnut (*Corylus americana*), beaked hazelnut (*C. cornuta*), hawthorn species (*Crataegus* spp.), huckleberry (*Gaylussacia baccata*), wild plum (*Prunus americana*), choke cherry (*P. virginiana*), sand cherry (*P. pumila*), dwarf chinquapin oak (*Quercus prinoides*), pasture rose (*Rosa carolina*), northern dewberry (*Rubus flagellaris*), prairie willow (*Salix humilis*), and low sweet blueberry (*Vaccinium angustifolium*). The ground layer is dominated by graminoids and forbs. Dominant species include little bluestem (*Andropogon scoparius*), big bluestem (*Andropogon gerardii*), and Pennsylvania sedge (*Carex pensylvanica*). Pennsylvania sedge often replaces the bluestems in shaded areas and fire-suppressed communities, especially north of the transition zone. Other prevalent herbs of oak-pine barrens include prairie heart-leaved aster (*Aster oolentangiensis*), false foxglove (*Aureolaria* spp.), tickseed (*Coreopsis lanceolata*), poverty grass (*Danthonia spicata*), hair grass (*Deschampsia flexuosa*), flowering spurge (*Euphorbia corollata*), woodland sunflower (*Helianthus divaricatus*), white pea (*Lathyrus ochroleucus*), hairy bush clover (*Lespedeza hirta*), cylindrical blazing star (*Liatris cylindracea*), wild lupine (*Lupinus perennis*), wild bergamot (*Monarda fistulosa*), wood betony (*Pedicularis canadensis*), and black oatgrass (*Stipa avenacea*). The flora of this community is a mixture of prairie and forest species, with prairie forbs and grasses more abundant in open areas and forest forbs and woody species more common in shaded areas.

Noteworthy Animals

Oak-pine barrens and surrounding prairie habitat once supported a rich diversity of invertebrates including numerous species of butterflies, skippers, grasshoppers, and locusts. Mound-building ants and numerous grassland birds also thrived in barrens and prairies. The fragmented and degraded status of Midwestern oak-pine barrens, savannas, and prairies has resulted in the drastic decline of numerous insect and bird species associated with savanna habitats and prairie/savanna host plants. Where large-scale herbivores were abundant, grazing may have helped inhibit the succession of oak-pine barrens to woodland and forest.

Rare Plants

Antennaria parvifolia (pussy-toes, state special concern)
Artemisia ludoviciana (western mugwort, state threatened)
Asclepias ovalifolia (dwarf milkweed, state endangered)
Aster sericeus (western silvery aster, state threatened)
Bouteloua curtipendula (side-oats grama grass, state endangered)
Carex inops ssp. *heliophila* (sun sedge, state special concern)
Carex tinctoria (sedge, state threatened)
Cirsium hillii (Hill's thistle, state special concern)
Festuca scabrella (rough fescue, state threatened)
Geum triflorum (prairie-smoke, state threatened)
Linum sulcatum (furrowed flax, state special concern)
Prunus alleghaniensis var. *davisii* (Alleghany plum, state special concern)

Rare Animals

Ammodramus savannarum (grasshopper sparrow, state special concern)
Atrytonopsis hianna (dusted skipper, state special concern)
Catocala amestris (three-staff underwing, state endangered)
Cryptotis parva (least shrew, state threatened)
Dendroica discolor (prairie warbler, state endangered)
Erynnis p. persius (Persius duskywing, state threatened)
Hesperia ottoe (ottoe skipper, state threatened)
Incisalia henrici (Henry's elfin, state threatened)
Incisalia irus (frosted elfin, state threatened)
Lepyronia gibbosa (Great Plains spittlebug, state special concern)
Lycaeides melissa samuelis (Karner blue, federal endangered and state threatened)
Microtus ochrogaster (prairie vole, state endangered)
Oecanthus pini (pinetree cricket, state special concern)
Orphulella p. pelidna (barrens locust, state special concern)
Papaipema sciata (Culver's root borer, state special concern)
Prosapia ignipectus (red-legged spittlebug, state special concern)
Pygarctia spraguei (Sprague's pygarctia, state special concern)
Pyrgus centaureae wyandot (grizzled skipper, state special concern)
Schinia indiana (phlox moth, state endangered)
Schinia lucens (leadplant flower moth, state endangered)
Scudderia fasciata (pine katydid, state special concern)
Sistrurus c. catenatus (eastern massasauga, federal candidate species and state special concern)
Speyeria idalia (regal fritillary, state endangered)
Terrapene c. carolina (eastern box turtle, state special concern)

Biodiversity Management Considerations

Fire is the single most significant factor in preserving oak-pine barrens landscapes. Where remnants of oak-pine barrens persist, the use of prescribed fire is an imperative management tool for maintaining an open canopy, promoting high levels of grass and forb diversity, deterring the encroachment of woody vegetation and invasive species, and limiting the success of canopy dominants. Fire intervals of one to three years bolster graminoid dominance, increase overall grass and forb diversity, and remove woody cover of saplings and shrubs. Burning at longer time intervals will allow for woody plant seedling establishment and persistence. Where rare species are a management concern, burning strategies should allow for ample refugia to facilitate effective post-burn recolonization. Fire management should be orchestrated in conjunction with that of adjacent fire-dependent upland and wetland communities such as dry sand prairie, coastal plain marsh, pine barrens, and dry northern forest. Degraded barrens that have been long deprived of fire often contain a heavy overstory component of shade-tolerant species, which can be removed by mechanical thinning or girdling. Restored sites can be maintained by periodic prescribed fire and may require investment in native plant seeding where seed and plant banks are inadequate.

Historically, Native Americans played an integral role in fire regimes of barrens ecosystems, intentionally and/or accidentally setting fire to savanna, barrens, and prairie ecosystems. Destructive timber exploitation of pines (1890s) and oaks (1920s) combined with post-logging slash fires and attempts to farm the droughty soils destroyed or degraded oak-pine barrens across Michigan. In addition, alteration of the historical fire regime has shifted many of the vegetation types with barrens physiognomy into woodlands and forest. Fire suppression policies instituted in the 1920s resulted in the succession of open oak-pine barrens to closed-canopy forests dominated by black and white oaks with little advanced regeneration of oaks and pines and a vanishing

graminoid component. Many sites formerly occupied by oak-pine barrens were also converted to pine plantations. The oak-pine barrens fragments that remain are often lacking the full complement of conifers, which were ubiquitously harvested. In addition to simplified overstory structure, these communities are often depauperate in floristic diversity as the result of fire suppression, livestock grazing, off-road vehicle activity, and the subsequent invasion of non-native species.

Monitoring and control efforts to detect and remove invasive species are critical to the long-term viability of oak-pine barrens. Invasive species that threaten the diversity and community structure of oak-pine barrens, especially in southern Lower Michigan, include common St. John's-wort (*Hypericum perforatum*), spotted knapweed (*Centaurea maculosa*), black swallow-wort (*Vincetoxicum nigrum*), white swallow-wort (*V. rossicum*), Canada bluegrass (*Poa compressa*), ox-eye daisy (*Chrysanthemum leucanthemum*), hoary alyssum (*Berteroa incana*), common buckthorn (*Rhamnus cathartica*), autumn olive (*Elaeagnus umbellata*), Eurasian honeysuckles (*Lonicera morrowii*, *L. japonica*, *L. maackii*, *L. sempervirens*, *L. tatarica*, *L. xbella*, and *L. xylosteum*), and multiflora rose (*Rosa multiflora*).

Variation

The oak-pine barrens community is a heterogeneous savanna community with variable physiognomy in time and space. Structurally, oak-pine barrens range from dense thickets of brush and understory scrub oak and pine among a matrix of grassland to park-like woodlands of widely spaced mature oaks and pines with virtually no tall-shrub or subcanopy layer above the open forb and graminoid-dominated ground flora. The physiognomic variations, which occur along a continuum, are the function of the complex interplay between fire frequency, fire intensity, and site factors (soils, landform, slope, aspect, etc).

Along the climatic tension zone and to the south, the most common overstory dominants are white oak, black oak, and white pine. North of the tension zone, northern pin oak replaces black oak, and red pine and jack pine become more prevalent in the canopy layer.

Similar Natural Communities

Bur oak plains, dry sand prairie, dry southern forest, dry northern forest, Great Lakes barrens, lakeplain oak openings, oak openings, oak barrens, and pine barrens.

Relevant Literature

- Chapman, K.A., M.A. White, M.R. Huffman and D. Faber-Langendoen. 1995. Ecology and stewardship guidelines for oak barrens landscapes in the upper Midwest. In Proceedings of the Midwest Oak Savanna Conference, 1993, ed. F. Stearns and K. Holland. U.S. Environmental Protection Agency, Internet Publications.
- Cohen, J.G. 2000. Natural community abstract for oak-pine barrens. Michigan Natural Features Inventory, Lansing, MI. 6 pp.
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For a full list of references used to create this description, please refer to the natural community abstract for oak-pine barrens.

Oak Barrens

Global/State Rank: G2?/S1

Overview

Oak barrens is a fire-dependent savanna type dominated by oaks, having between 5 and 60% canopy, with or without a shrub layer. Black oak (*Quercus velutina*) and white oak (*Q. alba*) typically dominate the scattered overstory. The predominantly graminoid ground layer is composed of species associated with both prairie and forest communities. Oak barrens are found on droughty soils and occur typically on nearly level to slightly undulating glacial outwash in southern Lower Michigan.

Landscape Context

Oak barrens occur on well-drained, nearly level to slightly undulating sandy glacial outwash, and less often on sandy moraines or ice-contact features. It is found in the southern Lower Peninsula in the driest landscape positions, such as ridge tops, steep slopes, south- to west-facing slopes, and flat sandplains. Oak barrens typically occur in bands surrounding prairie and grade into dry sand prairie on one edge and dry forest on the other.

Soils

Characteristic soils of oak barrens are infertile, coarse-textured, well-drained sand or loamy sand with medium to slightly acid pH and low water-retaining capacity. The drought soils contain little organic matter and lack the fine-textured illuvial horizon associated with the richer and more productive soils of the oak openings.

Natural Processes

Oak barrens likely originated when prairie fires spread into surrounding closed oak forest with enough intensity to create open barrens. Repeated low-intensity fires working in concert with drought, frost, and windthrow maintained oak savanna ecosystems. Fires prevented canopy closure and the dominance of woody vegetation. Fires in oak barrens and prairie typically occur during the spring, late summer, and fall. Flammability peaks bimodally, in the spring before grass and forb growth resumes and in the late summer and autumn after the above-ground biomass dies. Infrequent, high-intensity fires kill mature oaks and produce barrens covered by abundant, scrubby oak sprouts (i.e., oak grubs). Park-like barrens with widely spaced trees and an open grass-dominated ground flora are maintained by frequent, low-intensity fires that occur often enough to restrict growth of oak grubs into overstory trees.

Numerous biotic factors influence the patterning of vegetation of oak barrens. In addition to widely distributed overstory trees, barrens are characterized by scattered ant mounds. Mound-building ants play a crucial role in soil development of prairies, savannas, and barrens; ants mix and aerate the soil as they build tunnels and bring soil particles and nutrients to the topsoil from lower soil horizons. Herbivores can limit woody establishment and growth. With their flammable properties, grasses and forbs help maintain the annual fire regime. Open canopy conditions are also preserved by the development of a dense herbaceous litter, which limits tree seedling establishment. Overstory trees influence vegetative composition by affecting the distribution of nutrients, light, and moisture.

Vegetation

The canopy layer generally varies from 5 to 60% cover and is dominated or codominated by black oak and white oak. These species of oak are also prevalent as multi-stemmed shrubs of stump-sprout origin, especially in areas of high fire intensity. In addition, red maple (*Acer rubrum*), black cherry (*Prunus serotina*), big-toothed aspen (*Populus grandidentata*), quaking aspen (*P. tremuloides*), scarlet oak (*Q. coccinea*), and northern pin oak (*Q. ellipsoidalis*) are often found in the overstory and subcanopy of this community. Northern pin oak is especially common on excessively well-drained, infertile sites. Prevalent species of the subcanopy layer include hickory species (*Carya* spp.), dogwood species (*Cornus* spp.), cherry species (*Prunus* spp.), and sassafras (*Sassafras albidum*). Characteristic shrubs include serviceberry (*Amelanchier* spp.), bearberry (*Arctostaphylos uva-ursi*), New Jersey tea (*Ceanothus americanus*), sweetfern (*Comptonia peregrina*), dogwood species, American hazelnut (*Corylus americana*), beaked hazelnut (*C. cornuta*), hawthorn species (*Crataegus* spp.), wintergreen (*Gaultheria procumbens*), huckleberry (*Gaylussacia baccata*), wild plum (*Prunus americana*), choke cherry (*P. virginiana*), sand cherry (*P. pumila*), dwarf chinquapin oak (*Quercus prinoides*), shining sumac (*Rhus copallina*), pasture rose (*Rosa carolina*), northern dewberry (*Rubus flagellaris*), prairie willow (*Salix humilis*), and low sweet blueberry (*Vaccinium angustifolium*). The ground layer is dominated by graminoids and forbs. Common species include little bluestem (*Andropogon scoparius*), big bluestem (*Andropogon gerardii*), and Pennsylvania sedge (*Carex pensylvanica*), with Pennsylvania sedge often replacing the bluestems in shaded areas and fire-suppressed communities. Other prevalent herbs of the oak barrens include prairie heart-leaved aster (*Aster oolentangiensis*), false foxglove (*Aureolaria* spp.), tickseed (*Coreopsis lanceolata*), slender sand sedge (*Cyperus filiculmis*), poverty grass (*Danthonia spicata*), hair grass (*Deschampsia flexuosa*), flowering spurge (*Euphorbia corollata*), woodland sunflower (*Helianthus divaricatus*), June grass (*Koeleria macrantha*), false dandelion (*Krigia biflora*), white pea (*Lathyrus ochroleucus*), hairy bush clover (*Lespedeza hirta*), rough blazing star (*Liatris aspera*), dwarf blazing star (*L. cylindrica*), wild lupine (*Lupinus perennis*), wild bergamot (*Monarda fistulosa*), panic grass (*Panicum implicatum*), wood betony (*Pedicularis canadensis*), black oatgrass (*Stipa avenacea*), porcupine grass (*S. spartea*), goats-rue (*Tephrosia virginiana*), and birdfoot violet (*Viola pedata*). The flora of this community is a mixture of prairie and forest species, with prairie forbs and grasses more abundant in areas of high light and forest forbs and woody species in the areas of low light. The invasive plants spotted knapweed (*Centaurea maculosa*) and common St. John's-wort (*Hypericum perforatum*) are becoming increasingly common, especially along roadsides and trails through the community.

Noteworthy Animals

Oak barrens and surrounding prairie habitat once supported a rich diversity of invertebrates including numerous species of butterflies, skippers, grasshoppers, and locusts. Mound-building ants and numerous grassland birds also once thrived in barrens and prairies. The fragmented and degraded status of Midwestern oak barrens, savannas, and prairies has resulted in the drastic decline of numerous insect and bird species associated with these habitats and their host plants. The now extinct passenger pigeon (*Ectopistes migratorius*) was likely a keystone species in oak ecosystems, roosting in oaks by the thousands. Where large herbivores were abundant, grazing may have helped inhibit the succession of oak barrens to woodland or forest.

Rare Plants

Agalinis gattingeri (Gattinger's gerardia, state endangered)
Androsace occidentalis (rock-jasmine, state endangered)
Arabis missouriensis var. *deamii* (Missouri rock-cress, state special concern)
Aristida tuberculosa (beach three-awned grass, state endangered)
Artemisia ludoviciana (western mugwort, state threatened)

Aster drummondii (Drummond's aster, state threatened)
Aster sericeus (western silvery aster, state threatened)
Astragalus canadensis (Canadian milk vetch, state threatened)
Astragalus neglectus (Cooper's milk vetch, state special concern)
Baptisia leucophaea (cream wild indigo, state endangered)
Botrychium pallidum (pale moonwort, state special concern)
Bouteloua curtipendula (side-oats grama grass, state endangered)
Buchnera americana (blue-hearts, presumed extirpated from Michigan)
Carex gravida (sedge, presumed extirpated from Michigan)
Carex inops ssp. *heliophila* (sun sedge, state special concern)
Carex richardsonii (Richardson's sedge, state special concern)
Celtis tenuifolia (dwarf hackberry, state special concern)
Cerastium velutinum (field chickweed, presumed extirpated from Michigan)
Cirsium hillii (Hill's thistle, state special concern)
Commelina erecta (slender day-flower, presumed extirpated from Michigan)
Cuscuta indecora (dodder, state special concern)
Cuscuta pentagona (dodder, state special concern)
Dalea purpurea (purple prairie-clover, presumed extirpated from Michigan)
Dasistoma macrophylla (mullein foxglove, state endangered)
Dennstaedtia punctilobula (hay-scented fern, state threatened)
Eupatorium sessilifolium (upland boneset, state threatened)
Euphorbia commutata (tinted spurge, state threatened)
Gentiana flavida (white gentian, state endangered)
Gentiana puberulenta (downy gentian, state endangered)
Geum triflorum (prairie-smoke, state threatened)
Gillenia trifoliata (Bowman's root, state endangered)
Helianthus hirsutus (whiskered sunflower, state special concern)
Helianthus microcephalus (small wood sunflower, presumed extirpated from Michigan)
Helianthus mollis (downy sunflower, state threatened)
Hieracium paniculatum (panicked hawkweed, state threatened)
Houstonia caerulea (bluets, presumed extirpated from Michigan)
Ipomoea pandurata (wild potato-vine, state threatened)
Kuhnia eupatorioides (false boneset, state threatened)
Lactuca floridana (woodland lettuce, state threatened)
Lechea minor (least pinweed, presumed extirpated from Michigan)
Lechea stricta (erect pinweed, state special concern)
Lespedeza procumbens (trailing bush-clover, presumed extirpated from Michigan)
Linum sulcatum (furrowed flax, state special concern)
Linum virginianum (Virginia flax, state threatened)
Onosmodium molle (marbleweed, presumed extirpated from Michigan)
Pantherophis spiloides (gray ratsnake, state special concern)
Paronychia fastigiata (low-forked chickweed, presumed extirpated from Michigan)
Penstemon calycosus (smooth beard-tongue, state threatened)
Penstemon pallidus (pale beard-tongue, state special concern)
Phlox bifida (cleft phlox, presumed extirpated from Michigan)
Prunus alleghaniensis var. *davisii* (Alleghany plum, state special concern)
Scutellaria incana (downy skullcap, presumed extirpated from Michigan)
Silene stellata (starry campion, state threatened)
Silene virginica (fire pink, state endangered)
Sisyrinchium strictum (blue-eyed-grass, state special concern)
Solidago bicolor (white goldenrod, state endangered)

Sporobolus clandestinus (dropseed, state endangered)
Tradescantia virginiana (Virginia spiderwort, state special concern)
Trichostema dichotomum (bastard pennyroyal, state threatened)
Triplasis purpurea (sand grass, state special concern)

Rare Animals

Ammodramus savannarum (grasshopper sparrow, state special concern)
Atrytonopsis hianna (dusted skipper, state special concern)
Catocala amestris (three-staff underwing, state endangered)
Cryptotis parva (least shrew, state threatened)
Dendroica discolor (prairie warbler, state endangered)
Erynnis p. persius (Persius duskywing, state threatened)
Hesperia ottoe (ottoe skipper, state threatened)
Incisalia henrici (Henry's elfin, state threatened)
Incisalia irus (frosted elfin, state threatened)
Lepyronia gibbosa (Great Plains spittlebug, state special concern)
Lycaeides melissa samuelis (Karner blue, federal endangered and state threatened)
Microtus ochrogaster (prairie vole, state endangered)
Oecanthus pini (pinetree cricket, state special concern)
Orphulella p. pelidna (barrens locust, state special concern)
Papaipema sciata (Culver's root borer, state special concern)
Prosapia ignipectus (red-legged spittlebug, state special concern)
Pygarctia spraguei (Sprague's pygarctia, state special concern)
Pyrgus centaureae wyandot (grizzled skipper, state special concern)
Schinia indiana (phlox moth, state endangered)
Schinia lucens (leadplant flower moth, state endangered)
Scudderia fasciata (pine katydid, state special concern)
Sistrurus c. catenatus (eastern massasauga, federal candidate species and state special concern)
Speyeria idalia (regal fritillary, state endangered)
Terrapene c. carolina (eastern box turtle, state special concern)

Biodiversity Management Considerations

Fire is the single most significant factor in preserving the oak barrens landscapes. Where remnants of oak barrens persist, the use of prescribed fire is an imperative management tool for maintaining an open canopy, promoting high levels of grass and forb diversity, deterring the encroachment of woody vegetation and invasive species, and limiting the success of dominants. Fire intervals of one to three years bolster graminoid dominance, increase overall grass and forb diversity, and remove woody cover of saplings and shrubs. Burning at longer time intervals will allow for woody plant seedling establishment and persistence. Where rare animal species are a management concern, burning strategies should allow for ample refugia to facilitate effective post-burn recolonization. When feasible, fire management of oak barrens should include burning adjacent communities as well, including dry sand prairie, dry southern forest, oak-pine barrens, coastal plain marsh, intermittent wetland, bog, prairie fen, and southern wet meadow.

Degraded barrens that have been long deprived of fire often contain a heavy overstory component of shade-tolerant species, which can be removed by mechanical thinning or girdling. Restored sites will need to be maintained by periodic prescribed fire and may require investment in native plant seeding where seed and plant banks are inadequate.

Historically, Native Americans played an integral role in fire regimes of oak savanna and barrens ecosystems, intentionally and/or accidentally setting fires. Oak barrens have been cleared for sand

mining, agriculture, and residential and urban development. Alteration of historic fire regimes has shifted most barrens types into woodlands and forest. Wildfire suppression policies instituted in the 1920s in concert with road construction, expansion of towns, and increased agriculture caused a dramatic decrease in fire frequency and intensity. The reduction of fire in the landscape resulted in the succession of open oak barrens to closed-canopy forests dominated by black and white oaks with little advanced regeneration of oaks and a vanishing graminoid component. In addition, timber exploitation of oaks in the 1920s destroyed or degraded oak barrens across Michigan. Many oak barrens fragments are currently completely dominated by black oak as the result of selective harvest of canopy white oak. In addition to simplified overstory structure, these communities are often depauperate in floristic diversity as the result of fire suppression and subsequent woody encroachment, livestock grazing, off-road vehicle activity, and the invasion of non-native species. Ground layer vegetation of barrens remnants has been inhibited by low levels of light filtering through the dense overstories and impenetrable understories (often dominated by invasive shrubs) and by the thick litter layers that have accumulated from nearly a century of fire suppression.

Monitoring and control efforts to detect and remove invasive species are critical to the long-term viability of oak barrens. Invasive species that threaten the diversity and community structure include common St. John's-wort, spotted knapweed, black swallow-wort (*Vincetoxicum nigrum*), white swallow-wort (*V. rossicum*), Canada bluegrass (*Poa compressa*), ox-eye daisy (*Chrysanthemum leucanthemum*), hawkweeds (*Hieracium* spp.), sheep sorrel (*Rumex acetosella*), hoary alyssum (*Berteroa incana*), Oriental bittersweet (*Celastrus orbiculatus*), common buckthorn (*Rhamnus cathartica*), bouncing bet (*Saponaria officinalis*), autumn olive (*Elaeagnus umbellata*), Eurasian honeysuckles (*Lonicera morrowii*, *L. japonica*, *L. maackii*, *L. sempervirens*, *L. tatarica*, *L. xbella*, and *L. xylosteum*), and multiflora rose (*Rosa multiflora*).

Variation

The oak barrens community is a heterogeneous savanna vegetation type with variable physiognomy in time and space. Structurally, oak barrens range from dense thickets of brush and understory scrub oak within a matrix of grassland to park-like open woodlands of widely spaced mature oak and virtually no shrub or subcanopy layer above the open graminoid and forb ground flora. The physiognomic variations, which occur along a continuum, are the function of the complex interplay between fire frequency, fire intensity, and site conditions. Scarlet oak may be present in oak barrens on the southeast Lower Michigan lakeplain, where the community is limited to dry beach ridges.

Similar Natural Communities

Bur oak plains, dry sand prairie, dry-mesic prairie, dry southern forest, lakeplain oak openings, oak openings, oak-pine barrens, and pine barrens.

Relevant Literature

- Anderson, M.D., and L.E. Brown. 1983. Comparative effects of fire on trees in a Midwestern savannah and an adjacent forest. *Bulletin of the Torrey Botanical Club* 119(1): 19-28.
- Bowles, M.L., and J.L. McBride. 1998. Vegetation composition, structure, and chronological change in a decadent Midwestern North American savanna remnant. *Natural Areas Journal* 18(1): 14-27.
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For a full list of references used to create this description, please refer to the natural community abstract for oak barrens.

Oak Openings

Global/State Rank: G1/S1

Overview

Oak openings are fire-dependent savannas dominated by oaks, having between 10 and 60% canopy, with or without a shrub layer. The predominantly graminoid ground layer is composed of species associated with both prairie and forest communities. Oak openings are found on dry-mesic loams in the southern Lower Peninsula, typically occurring on level to rolling topography of outwash and coarse-textured end moraines. Oak openings have been nearly extirpated from Michigan; only one small example remains. They are known primarily from historical literature and data derived from severely disturbed sites.

Landscape Context

Oak openings occurred in the southern Lower Peninsula primarily on level to rolling topography of glacial outwash plains and coarse-textured end moraines and occasionally on steep slopes of ice-contact features. They were most prevalent on the western side of major firebreaks such as rivers. Oak openings and associated dry-mesic prairie once occurred adjacent to more mesic communities, such as bur oak plains, mesic prairie, and wet-mesic prairie and also likely graded into oak barrens, a drier savanna type, as well as dry-mesic southern forest and dry southern forest. Historically, oak openings occurred in a complex, shifting mosaic of upland and wetland plant communities that depended on frequent fire for maintaining open and semi-open conditions.

Soils

Soils of oak openings are well-drained, moderately fertile, sandy loams, or loams with slightly acid to neutral pH and low to moderate water-retaining capacity.

Natural Processes

Repeated low-intensity fires, working in concert with drought and windthrow, maintained open conditions in oak savanna ecosystems. Within dry-mesic savanna systems, such as oak openings, it is likely that annual or nearly annual fire disturbance was the primary abiotic factor influencing savanna structure and composition. Oak openings were found primarily on level to undulating topography, a landscape in which fires occurred frequently and spread rapidly and evenly. Fires prevented canopy closure and limited the dominance of woody vegetation. Oak savanna and prairie fires occur during the spring, late summer, and fall. Flammability peaks in the spring before grass and forb growth resumes and then again in the late summer and autumn after the above-ground biomass dies back.

Numerous biotic factors influence the patterning of vegetation of oak savannas. In addition to widely distributed overstory trees, savannas are characterized by scattered ant mounds. Mound-building ants play a crucial role in the soil development of prairies and savannas; ants mix and aerate the soil as they build tunnels and bring soil particles and nutrients to the topsoil from lower soil horizons. Herbivores can limit woody establishment and encroachment. With their flammable properties, grasses and forbs help maintain the annual fire regime. Open canopy conditions are also preserved by the development of dense herbaceous litter, which limits tree seedling establishment. Overstory trees influence vegetative composition by affecting the distribution of nutrients, light, and moisture.

Vegetation

Oak openings were described by Michigan settlers as park-like savannas of widely spaced mature oaks, with a wide range of shrub cover above the forb and graminoid ground layer. The broad-crowned, scattered oaks were typically of the same age cohort and the canopy layer generally varied from 10 to 60% cover. The canopy was dominated by white oak (*Quercus alba*) with codominants including bur oak (*Q. macrocarpa*) and chinquapin oak (*Q. muehlenbergii*). Important canopy associates included pignut hickory (*Carya glabra*), shagbark hickory (*C. ovata*), red oak (*Q. rubra*), and black oak (*Q. velutina*). Oaks, especially black oak, although widely dispersed in the oak openings, were limited to fire-suppressed grubs that often reached just over a meter tall. Scattered or clumped shrubs ranged from 0 to 50% cover depending on fire frequency. The most common shrubs were fire-tolerant species such as American hazelnut (*Corylus americana*), New Jersey tea (*Ceanothus americanus*), and leadplant (*Amorpha canescens*, state special concern). Shrubs such as gray dogwood (*Cornus foemina*), wild plum (*Prunus americana*), and smooth sumac (*Rhus glabra*) occasionally formed thickets in fire-protected microsites. Oak openings were characterized by a discontinuous layer of trees and shrubs and a continuous herbaceous layer. The flora of savannas were a mixture of prairie and forest species, with prairie forbs and grasses more abundant in open areas and forest forbs and woody species more common in shaded areas. Many of the species of oak savanna were, in fact, savanna specialists that thrived in the mottled light conditions provided by the scattered oak canopy. The ground layer of these systems was dominated by a diverse array of graminoids and forbs. Common grasses included big bluestem (*Andropogon gerardii*), little bluestem (*Andropogon scoparius*), and Indian grass (*Sorghastrum nutans*). Prevalent forbs included hog-peanut (*Amphicarpaea bracteata*), thimbleweed (*Anemone cylindrica*), purple milkweed (*Asclepias purpurascens*, state threatened), butterfly-weed (*A. tuberosa*), smooth aster (*Aster laevis*), frost aster (*A. pilosus*), prairie coreopsis (*Coreopsis palmata*, state threatened), showy tick-trefoil (*Desmodium canadense*), upland boneset (*Eupatorium sessilifolium*, state threatened), daisy fleabane (*Erigeron strigosus*), flowering spurge (*Euphorbia corollata*), northern bedstraw (*Galium boreale*), white gentian (*Gentiana flavida*, state endangered), false boneset (*Kuhnia eupatorioides*, state special concern), veiny pea (*Lathyrus venosus*), bush clovers (*Lespedeza capitata* and *L. hirta*), wild-bergamot (*Monarda fistulosa*), Virginia mountain mint (*Pycnanthemum virginianum*), black-eyed Susan (*Rudbeckia hirta*), starry campion (*Silene stellata*, state threatened), early goldenrod (*Solidago juncea*), yellow pimpernel (*Taenidia integerrima*), feverwort (*Triosteum perfoliatum*), Culver's root (*Veronicastrum virginicum*), and golden alexanders (*Zizia aurea*).

Noteworthy Animals

Oak openings and surrounding prairie habitat once supported a rich diversity of invertebrates including numerous butterflies, skippers, grasshoppers, and locusts. Mound-building ants and numerous grassland birds also thrived in savannas and prairies. The fragmented and degraded status of Midwestern oak savannas and prairies has resulted in the drastic decline of numerous insect and bird species associated with savanna habitats and prairie/savanna host plants. The now extinct passenger pigeon (*Ectopistes migratorius*) was likely a keystone species in oak ecosystems, roosting in oaks by the thousands.

Rare Plants

Amorpha canescens (leadplant, state special concern)
Asclepias purpurascens (purple milkweed, state threatened)
Aster sericeus (western silvery aster, state threatened)
Baptisia lactea (white false indigo, state special concern)
Baptisia leucophaea (cream wild indigo, state endangered)
Bouteloua curtipendula (side-oats grama grass, state endangered)

Camassia scilloides (wild-hyacinth, state threatened)
Cerastium velutinum (field chickweed, presumed extirpated from Michigan)
Corydalis flavula (yellow fumewort, state threatened)
Dennstaedtia punctilobula (hay-scented fern, state threatened)
Eryngium yuccifolium (rattlesnake-master, state threatened)
Eupatorium sessilifolium (upland boneset, state threatened)
Euphorbia commutata (tinted spurge, state threatened)
Gentiana flavida (white gentian, state endangered)
Gentiana puberulenta (downy gentian, state endangered)
Geum triflorum (prairie-smoke, state threatened)
Helianthus microcephalus (small wood sunflower, presumed extirpated from Michigan)
Helianthus mollis (downy sunflower, state threatened)
Hieracium paniculatum (panicked hawkweed, state threatened)
Houstonia caerulea (bluets, presumed extirpated from Michigan)
Kuhnia eupatorioides (false boneset, state special concern)
Lactuca floridana (woodland lettuce, state threatened)
Lechea minor (least pinweed, presumed extirpated from Michigan)
Lechea stricta (erect pinweed, state special concern)
Linum sulcatum (furrowed flax, state special concern)
Onosmodium molle (marbleweed, presumed extirpated from Michigan)
Oxalis violacea (violet wood-sorrel, presumed extirpated from Michigan)
Panicum leibergii (Leiberg's panic grass, state threatened)
Polytaenia nuttallii (prairie-parsley, presumed extirpated from Michigan)
Ranunculus rhomboideus (prairie buttercup, state threatened)
Rudbeckia subtomentosa (sweet coneflower, presumed extirpated from Michigan)
Ruellia humilis (hairy ruellia, state threatened)
Scutellaria elliptica (hairy skullcap, state special concern)
Silene stellata (starry campion, state threatened)
Sisyrinchium strictum (blue-eyed-grass, state special concern)
Sporobolus clandestinus (dropseed, state endangered)
Tomanthera auriculata (eared false foxglove, presumed extirpated from Michigan)
Trichostema dichotomum (bastard pennyroyal, state threatened)

Rare Animals

Ammodramus henslowii (Henslow's sparrow, state endangered)
Ammodramus savannarum (grasshopper sparrow, state special concern)
Atrytonopsis hianna (dusted skipper, state special concern)
Catocala amestris (three-staff underwing, state endangered)
Clonophis kirtlandii (Kirtland's snake, state endangered)
Cryptotis parva (least shrew, state threatened)
Dendroica discolor (prairie warbler, state endangered)
Erynnis p. persius (Persius duskywing, state threatened)
Hesperia ottoe (ottoe skipper, state threatened)
Incisalia henrici (Henry's elfin, state threatened)
Incisalia irus (frosted elfin, state threatened)
Lanius ludovicianus migrans (migrant loggerhead shrike, state endangered)
Lepyronia gibbosa (Great Plains spittlebug, state special concern)
Lycaeides melissa samuelis (Karner blue, federal endangered and state threatened)
Microtus ochrogaster (prairie vole, state endangered)
Myotis sodalis (Indiana bat, federal/state endangered)
Neoconocephalus ensiger (conehead grasshopper, state special concern)

Nicrophorus americanus (American burying water beetle, presumed extirpated from Michigan)
Oecanthus pini (pinetree cricket, state special concern)
Orphulella p. pelidna (barrens locust, state special concern)
Pantherophis spiloides (gray ratsnake, state special concern)
Papaipema beeriana (Blazing star borer, state special concern)
Papaipema sciata (Culver's root borer, state special concern)
Prosapia ignipectus (red-legged spittlebug, state special concern)
Pygarctia spraguei (Sprague's pygarctia, state special concern)
Pyrgus centaureae wyandot (grizzled skipper, state special concern)
Schinia indiana (phlox moth, state endangered)
Schinia lucens (leadplant flower moth, state endangered)
Scudderia fasciata (pine katydid, state special concern)
Sistrurus c. catenatus (eastern massasauga, federal candidate species and state special concern)
Spartiniphaga inops (spartina moth, state special concern)
Speyeria idalia (regal fritillary, state endangered)
Terrapene c. carolina (eastern box turtle, state special concern)
Tympanuchus phasianellus (sharp-tailed grouse, state special concern)
Tyto alba (barn owl, state endangered)

Biodiversity Management Considerations

The prime conservation priority for this globally imperiled community is to survey for restorable remnants. The existence of oak savanna depends on active restoration; this is especially true for oak openings. If remnants of oak openings are located, the first management step will be the restoration of the oak savanna physiognomy through prescribed fire and/or selective cutting or girdling. The process of restoring the open canopy conditions and eliminating the understory should be conducted gradually, undertaken over the course of several years taking care to minimize colonization by invasive plants, which can respond rapidly to increased levels of light and soil disturbance. Fire is the single most significant factor in preserving oak-savanna landscapes. In addition to maintaining open canopy conditions, prescribed fire promotes internal vegetative patchiness and high levels of grass and forb diversity, and deters the encroachment of woody vegetation and invasive plants. Numerous studies have indicated that fire intervals of one to three years bolster graminoid dominance, increase overall grass and forb diversity, and remove woody cover of saplings and shrubs.

Savannas were among some of the first locations chosen for settlement by early Europeans. Many towns, college campuses, parks, and cemeteries of the Midwest were established on former oak savanna. Early settlers of Michigan utilized oak openings for growing crops, pasturing livestock, and harvesting timber for fuel and building supplies. Alteration of historic fire regimes quickly shifted most oak savannas to closed-canopy oak forests. Oak savanna remnants are often depauperate in floristic diversity due to past disturbances and colonization by invasive species, many of which are shrubs that create dense shade and suppress or eliminate the graminoid species needed to carry fire.

Monitoring and control efforts to detect and remove invasive species are critical to the success of restoration projects. Invasive species that threaten the diversity and community structure of oak openings include spotted knapweed (*Centaurea maculosa*), common St. John's-wort (*Hypericum perforatum*), black swallow-wort (*Vincetoxicum nigrum*), white swallow-wort (*V. rossicum*), Kentucky bluegrass (*Poa pratensis*), Canada bluegrass (*P. compressa*), ox-eye daisy (*Chrysanthemum leucanthemum*), hawkweeds (*Hieracium* spp.), sheep sorrel (*Rumex acetosella*), bouncing bet (*Saponaria officinalis*), hoary alyssum (*Berteroa incana*), Oriental bittersweet (*Celastrus orbiculatus*), common buckthorn (*Rhamnus cathartica*), autumn olive (*Elaeagnus*

umbellata), Eurasian honeysuckles (*Lonicera morrowii*, *L. japonica*, *L. maackii*, *L. sempervirens*, *L. tatarica*, *L. xbella*, and *L. xylosteum*), and multiflora rose (*Rosa multiflora*).

Variation

The character of oak savanna ecosystems can differ dramatically, primarily as the result of varying fire intensity and fire frequency, which are influenced by site factors such as climatic conditions, soil texture, topography, size of physiographic and vegetative units, and landscape context (e.g., proximity to water bodies). Infrequent, high-intensity fires kill mature oaks and produce savannas covered by abundant scrubby oak sprouts. Park-like openings with widely spaced trees and a graminoid- and forb-dominated ground layer are maintained by frequent, low-intensity fires that occur often enough to restrict maturation of oak grubs and encroachment by other woody species.

Similar Natural Communities

Bur oak plains, dry-mesic southern forest, lakeplain oak openings, mesic prairie, oak barrens, oak-pine barrens, and dry-mesic prairie.

Relevant Literature

- Anderson, R.C., and M.L. Bowles. 1999. Deep-soil savannas and barrens of the Midwestern United States. Pp. 155-170 in *Savannas, barrens, and rock outcrop plant communities of North America*, ed. R.C. Anderson, J.S. Fralish, and J.M. Baskin. Cambridge University Press, Cambridge, UK. 480 pp.
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For a full list of references used to create this description, please refer to the natural community abstract for oak openings.

Bur Oak Plains

Global/State Rank: G1/SX

Overview

Bur oak plains was a fire-dependent, savanna community dominated by oaks, having between 10 and 30% canopy, with or without a shrub layer. The predominantly graminoid ground layer was comprised of species associated with both prairie and forest communities. Bur oak plains were found on mesic loams and typically occurred on level to slightly undulating sandy glacial outwash, and on river terraces. Bur oak plains have been extirpated from Michigan and are now known only from historical literature and data derived from severely disturbed sites.

Landscape Context

This natural community occurred on level to gently undulating or sloping glacial outwash plains, and also on river terraces, typically on the river's western side, where fire frequency was highest. Bur oak plains occurred adjacent to more mesic communities, such as mesic prairie and wet-mesic prairie and also graded into the drier savanna and forest types such as oak openings and oak barrens, and dry-mesic southern forest and dry southern forest. Historically, bur oak plains occurred in a complex, shifting mosaic of fire-dependent upland and wetland communities.

Soils

Soils were fertile, fine-textured, loam, sandy loam or silt loam with neutral pH and good water-retaining capacity. Soils contained moderate to high amounts of organic matter and supported high abundance of graminoids and forbs.

Natural Processes

Repeated low-intensity fires working in concert with drought and windthrow maintained oak savanna ecosystems. Within mesic savanna systems, such as bur oak plains, it is likely that annual or semi-annual fires were the primary factor influencing savanna structure and composition. Fires prevented canopy closure and the dominance of woody vegetation. Bur oak plains were found primarily on level to gently rolling topography of outwash plains, a landscape in which fires occurred frequently and spread rapidly and evenly. The rich mesic soils of bur oak plains supported high coverage of grass and forb fuels. The frequent fire regime within these systems explains the canopy dominance of bur oak, which is the most fire resistant of the oaks with its deep roots, capacity to resprout, and thick, corky, insulating bark that prevents cambial damage by surface fires.

Oak savanna and prairie fires occur most often during the spring, late summer, and fall. Flammability peaks in the spring before grass and forb growth resumes and then again in the late summer and autumn after the above-ground biomass dies. Numerous biotic factors influence the patterning of vegetation of oak savannas. In addition to widely distributed overstory trees, savannas are characterized by scattered ant mounds. Mound-building ants play a crucial role in the soil development of prairies and savannas; ants mix and aerate the soil as they build tunnels and bring soil particles and nutrients to the topsoil from the subsoil. Herbivores can limit woody establishment and encroachment. Grasses and forbs help maintain the annual fire regime with their flammable properties. Open canopy conditions are also preserved by the development of a dense herbaceous litter that suspends tree propagules and interferes with the ability of radicles to reach the soil surface. Savanna trees influence vegetative composition by affecting the distribution of nutrients, light, and moisture.

Vegetation

Vegetation was described by Michigan settlers as park-like savanna of widely spaced mature oaks with virtually no shrub or subcanopy layer above the forb and graminoid layer. The broad-crowned, scattered oaks were typically of the same age cohort. The canopy layer generally varied from 10 to 30% cover and was dominated by bur oak (*Quercus macrocarpa*) and occasionally codominated by white oak (*Q. alba*). Canopy associates were limited to scattered hickories (*Carya* spp.) and black oak (*Q. velutina*). Oaks, especially black oak, were dispersed in the understory as fire-suppressed grubs that reached just over a meter tall. Shrubs occurred scattered or clumped in the understory. The most common shrubs were fire-tolerant species such as American hazelnut (*Corylus americana*), New Jersey tea (*Ceanothus americanus*), and leadplant (*Amorpha canescens*, state special concern). Shrubs such as gray dogwood (*Cornus foemina*), wild plum (*Prunus americana*), and smooth sumac (*Rhus glabra*) occasionally formed thickets in fire-protected microsites. Bur oak plains were characterized by a discontinuous layer of trees and shrubs and a continuous herbaceous layer. The flora of savannas were a mixture of prairie and forest species, with prairie forbs and grasses more abundant in high light areas and forest forbs and woody species in the areas of low light. Common grass species included big bluestem (*Andropogon gerardii*), little bluestem (*Andropogon scoparius*), and Indian grass (*Sorghastrum nutans*). Prevalent forbs included hog-peanut (*Amphicarpaea bracteata*), purple milkweed (*Asclepias purpurascens*, state threatened), prairie coreopsis (*Coreopsis palmata*, state threatened), showy tick-trefoil (*Desmodium canadense*), upland boneset (*Eupatorium sessilifolium*, state threatened), flowering spurge (*Euphorbia corollata*), northern bedstraw (*Galium boreale*), white gentian (*Gentiana flavida*, state endangered), false boneset (*Kuhnia eupatorioides*, state special concern), veiny pea (*Lathyrus venosus*), round-headed bush clover (*Lespedeza capitata*), wild-bergamot (*Monarda fistulosa*), Virginia mountain mint (*Pycnanthemum virginianum*), starry campion (*Silene stellata*, state threatened), yellow pimpernel (*Taenidia integerrima*), horse-gentian (*Triosteum aurantiacum*), feverwort (*T. perfoliatum*), and golden alexanders (*Zizia aurea*).

Noteworthy Animals

Bur oak plains and surrounding prairie habitat once supported a rich diversity of invertebrates including numerous species of butterflies, skippers, grasshoppers, and locusts. Mound-building ants and numerous grassland birds also thrived in savannas and prairies. The fragmented and degraded status of Midwestern oak savannas and prairies has resulted in the drastic decline of numerous insect and bird species associated with savanna habitats and prairie/savanna host plants. The now extinct passenger pigeon (*Ectopistes migratorius*) was likely a keystone species in oak ecosystems, roosting in oaks by the thousands.

Rare Plants

Amorpha canescens (leadplant, state special concern)
Asclepias purpurascens (purple milkweed, state threatened)
Aster sericeus (western silvery aster, state threatened)
Baptisia leucophaea (cream wild indigo, state endangered)
Bouteloua curtipendula (side-oats grama grass, state endangered)
Camassia scilloides (wild-hyacinth, state threatened)
Coreopsis palmata (prairie coreopsis, state threatened)
Corydalis flavula (yellow fumewort, state threatened)
Dodecatheon meadia (shooting star, state endangered)
Eryngium yuccifolium (rattlesnake-master, state threatened)
Eupatorium sessilifolium (upland boneset, state threatened)
Euphorbia commutata (tinted spurge, state threatened)
Gentiana flavida (white gentian, state endangered)

Gentiana puberulenta (downy gentian, state endangered)
Geum triflorum (prairie-smoke, state threatened)
Helianthus mollis (downy sunflower, state threatened)
Hieracium paniculatum (panicked hawkweed, state threatened)
Kuhnia eupatorioides (false boneset, special concern)
Lechea minor (least pinweed, presumed extirpated from Michigan)
Lechea stricta (erect pinweed, state special concern)
Linum sulcatum (furrowed flax, state special concern)
Oxalis violacea (violet wood-sorrel, presumed extirpated from Michigan)
Rudbeckia subtomentosa (sweet coneflower, presumed extirpated from Michigan)
Silene stellata (starry campion, state threatened)
Sisyrinchium strictum (blue-eyed-grass, state special concern)
Sporobolus clandestinus (dropseed, state endangered)
Trichostema dichotomum (bastard pennyroyal, state threatened)

Rare Animals

Ammodramus henslowii (Henslow's sparrow, state endangered)
Ammodramus savannarum (grasshopper sparrow, state special concern)
Atrytonopsis hianna (dusted skipper, state special concern)
Catocala amestris (three-staff underwing, state endangered)
Circus cyaneus (northern harrier, state special concern)
Clonophis kirtlandii (Kirtland's snake, state endangered)
Cryptotis parva (least shrew, state threatened)
Dendroica discolor (prairie warbler, state endangered)
Erynnis p. persius (Persius duskywing, state threatened)
Hesperia ottoe (ottoe skipper, state threatened)
Incisalia henrici (Henry's elfin, state threatened)
Incisalia irus (frosted elfin, state threatened)
Lanius ludovicianus migrans (migrant loggerhead shrike, state endangered)
Lepyronia gibbosa (Great Plains spittlebug, state special concern)
Lycaeides melissa samuelis (Karner blue, federal endangered and state threatened)
Papaipema beeriana (Blazing star borer, state special concern)
Microtus ochrogaster (prairie vole, state endangered)
Myotis sodalis (Indiana bat, federal/state endangered)
Neoconocephalus ensiger (conehead grasshopper, state special concern)
Nicrophorus americanus (American burying water beetle, presumed extirpated from Michigan)
Oecanthus pini (pinetree cricket, state special concern)
Orphulella p. pelidna (barrens locust, state special concern)
Papaipema sciata (Culver's root borer, state special concern)
Prosapia ignipectus (red-legged spittlebug, state special concern)
Pygarcia spraguei (Sprague's pygarcia, state special concern)
Pyrgus centaureae wyandot (grizzled skipper, state special concern)
Schinia indiana (phlox moth, state endangered)
Schinia lucens (leadplant flower moth, state endangered)
Scudderia fasciata (pine katydid, state special concern)
Sistrurus c. catenatus (eastern massasauga, federal candidate species and state special concern)
Spartiniphaga inops (spartina moth, state special concern)
Speyeria idalia (regal fritillary, state endangered)
Terrapene c. carolina (eastern box turtle, state special concern)
Tympanuchus phasianellus (sharp-tailed grouse, state special concern)
Tyto alba (barn owl, state endangered)

Biodiversity Management Considerations

The prime conservation priority for this globally imperiled community is to survey for restorable remnants. The future existence of all oak savannas in Michigan depends upon active restoration; this is especially true for bur oak plains. If bur oak plains remnants are located, the first management step will be the restoration of savanna physiognomy through prescribed fire and/or selective cutting or girdling. The process of restoring the open canopy conditions and eliminating the understory should be conducted gradually, undertaken over the course of several years. Fire is the single most significant restoration tool. In addition to maintaining open canopy conditions, prescribed fire promotes internal vegetative patchiness and high levels of grass and forb diversity, and deters the encroachment of woody vegetation and invasive non-natives. Numerous studies have indicated that fire intervals of one to three years bolster graminoid dominance, increase overall grass and forb diversity, and remove woody cover of saplings and shrubs.

Variation

Pure stands of bur oak of relatively similar-sized trees occurred in flat mesic areas with high fuel loads that likely supported annual fires. White oak codominated in slightly drier, less fertile sites with sloping topography, where herbaceous fuels were less dense and fire intensity less severe.

Similar Natural Communities

Lakeplain oak openings, mesic prairie, oak barrens, oak-pine barrens, oak openings, and wet-mesic prairie.

Relevant Literature

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For a full list of references used to create this description, please refer to the natural community abstract for bur oak plains.

Lakeplain Oak Openings

Global/State Rank: G2?/S1

Overview

Lakeplain oak openings are a fire-dependent savanna community, dominated by oaks and characterized by a graminoid-dominated ground layer of species associated with both lakeplain prairie and forest communities. Lakeplain oak openings occur within the southern Lower Peninsula on glacial lakeplains on sand ridges, level sandplains, or adjacent depressions. Open conditions were historically maintained by frequent fire, and in depressions, by seasonal flooding.

Landscape Context

Lakeplain oak openings occur on dune features of sandy lakeplain in southern Lower Michigan. Lakeplain oak openings occur less commonly on silty/clayey glacial lakeplains with seasonally high water tables. Historically, lakeplain oak openings occurred in complex shifting mosaics with wet-mesic flatwoods, southern hardwood swamp, lakeplain wet prairie, lakeplain wet-mesic prairie, and mesic sand prairie, depending on water table fluctuations and fire frequency.

Soils

Soils are typically mildly alkaline, very fine sandy loams, loamy sands, or sands with moderate water-retaining capacity.

Natural Processes

Lakeplain oak openings persist when fire, hydrology, and/or drought prevent canopy closure. The character of lakeplain oak openings can differ dramatically, primarily as the result of varying fire intensity and frequency, which are influenced by climatic conditions, soil texture, topography, and landscape context (i.e., proximity to water bodies and fire-resistant or fire-conducting plant communities). Infrequent, high-intensity fires kill mature oaks and produce openings with abundant scrubby oak sprouts (i.e., oak grubs). Park-like openings, with widely spaced trees and an open grass understory, are maintained by frequent, low-intensity fires, which occur often enough to restrict maturation of oak grubs. Frequent, low-intensity fires also maintain high grass and forb diversity by deterring the encroachment of woody vegetation and limiting single species dominance. Presently, the prevalent catalyst of fires is lightning strike, but historically Native Americans played an integral role in the fire regime, accidentally and/or intentionally setting fire to savanna and prairie ecosystems. In low areas, seasonally high water levels play an important role in maintaining the open condition of lakeplain oak openings.

Vegetation

Dominant canopy species of droughty sand ridges are black oak (*Quercus velutina*) and white oak (*Q. alba*). Bur oak (*Quercus macrocarpa*), pin oak (*Q. palustris*), and swamp white oak (*Q. bicolor*) are prevalent on flat, poorly drained areas. Canopy and subcanopy associates of ridges include hickory species (*Carya* spp.), green ash (*Fraxinus pennsylvanica*), and sassafras (*Sassafras albidum*). Canopy associates of swales include green ash, silver maple (*Acer saccharinum*), red maple (*A. rubrum*), and cottonwood (*Populus deltoides*). The ground layer consists of species typical of mesic sand prairie and lakeplain wet-mesic prairie. Ground flora of sandy ridges is characterized by big bluestem (*Andropogon gerardii*), bluejoint grass (*Calamagrostis canadensis*), Pennsylvania sedge (*Carex pennsylvanica*), blazing star (*Liatris* spp.), little bluestem (*Andropogon scoparius*), and Indian grass (*Sorghastrum nutans*). Shrubs of sandy ridges include serviceberries (*Amelanchier* spp.), bearberry (*Arctostaphylos uva-ursi*), New Jersey tea (*Ceanothus americanus*), sweetfern (*Comptonia peregrina*), gray dogwood (*Cornus*

foemina), American hazelnut (*Corylus americana*), hawthorns (*Crataegus* spp.), huckleberry (*Gaylussacia baccata*), cherries (*Prunus* spp.), sumacs (*Rhus* spp.), northern dewberry (*Rubus flagellaris*), and blueberries (*Vaccinium* spp.). Common ground flora in swales includes bluejoint grass, tussock sedge (*Carex stricta*), water sedge (*C. aquatilis*), twig-rush (*Cladium mariscoides*), switch grass (*Panicum virgatum*), Virginia mountain mint (*Pycnanthemum virginianum*), and cordgrass (*Spartina pectinata*). Prevalent shrubs in swales include black chokeberry (*Aronia prunifolia*), buttonbush (*Cephalanthus occidentalis*), dogwoods (*Cornus* spp.), winterberry (*Ilex verticillata*), shrubby cinquefoil (*Potentilla fruticosa*), and willows (*Salix* spp.).

Noteworthy Animals

Lakeplain oak openings and surrounding lakeplain prairie habitat once supported a rich diversity of invertebrates including numerous butterflies, skippers, grasshoppers, and locusts. Mound-building ants and numerous species of grassland birds also thrived in savannas and prairies. The fragmented and degraded status of Midwestern oak savannas and prairies has resulted in the drastic decline of numerous insect and bird species associated with savanna habitats and prairie and savanna host plants. On lakeplains and outwash plains with streams, beaver (*Castor canadensis*) may have dramatically influenced the landscape by expanding wetland area, preventing the encroachment of woody species in seasonally flooded areas, and creating barriers to fire.

Rare Plants

Agalinis gattingeri (Gattinger's gerardia, state endangered)
Agalinis skinneriana (Skinner's gerardia, state endangered)
Angelica venenosa (hairy angelica, state special concern)
Arabis missouriensis var. *deamii* (Missouri rock-cress, state special concern)
Aristida longespica (three-awned grass, state threatened)
Asclepias purpurascens (purple milkweed, state threatened)
Astragalus neglectus (Cooper's milk vetch, state special concern)
Carex richardsonii (Richardson's sedge, state special concern)
Cerastium velutinum (field chickweed, presumed extirpated from Michigan)
Eupatorium sessilifolium (upland boneset, state threatened)
Euphorbia commutata (tinted spurge, state threatened)
Gentiana puberulenta (downy gentian, state endangered)
Helianthus hirsutus (whiskered sunflower, state special concern)
Helianthus mollis (downy sunflower, state threatened)
Hieracium paniculatum (panicled hawkweed, state threatened)
Hypericum gentianoides (gentian-leaved St. John's-wort, state special concern)
Lactuca floridana (woodland lettuce, state threatened)
Lechea minor (least pinweed, presumed extirpated from Michigan)
Leucospora multifida (conobea, state special concern)
Linum sulcatum (furrowed flax, state special concern)
Phaseolus polystachios (wild bean, presumed extirpated from Michigan)
Polygala cruciata (cross-leaved milkwort, state special concern)
Scirpus clintonii (Clinton's bulrush, state special concern)
Scleria pauciflora (few-flowered nut-rush, state endangered)
Scleria triglomerata (tall nut-rush, state special concern)
Sporobolus clandestinus (dropseed, state endangered)
Tradescantia virginiana (Virginia spiderwort, state special concern)

Rare Animals

Ammodramus savannarum (grasshopper sparrow, state special concern)
Atrytonopsis hianna (dusted skipper, state special concern)
Cryptotis parva (least shrew, state threatened)
Dendroica discolor (prairie warbler, state endangered)
Erynnis baptisiae (wild indigo duskywing, state special concern)
Erynnis p. persius (Persius duskywing, state threatened)
Euphyes dukesi (Duke's skipper, state threatened)
Lepyronia gibbosa (Great Plains spittlebug, state special concern)
Lycaeides melissa samuelis (Karner blue, federal endangered and state threatened)
Microtus ochrogaster (prairie vole, state endangered)
Pantherophis gloydi (eastern fox snake, state threatened)
Papaipema maritima (maritime sunflower borer, state special concern)
Papaipema sciata (Culver's root borer, state special concern)
Papaipema silphii (silphium borer moth, state threatened)
Prosapia ignipectus (red-legged spittlebug, state special concern)
Sistrurus c. catenatus (eastern massasauga, federal candidate species and state special concern)
Spartiniphaga inops (spartina moth, state special concern)
Terrapene c. carolina (eastern box turtle, state special concern)

Biodiversity Management Considerations

Use of prescribed fire and restoration of hydrologic processes is imperative for maintaining an open canopy, promoting high levels of grass and forb diversity, and deterring the encroachment of woody vegetation and invasive species. Filling of ditches can contribute to the restoration of hydrologic processes. Fire intervals of one to three years bolster graminoid dominance, increase overall grass and forb diversity, and remove woody cover of saplings and shrubs. Where rare invertebrates and herptiles are a management concern, burning strategies should allow for ample refugia to facilitate effective post-burn recolonization. Where feasible, fire management of lakeplain oak openings should include burning adjacent lakeplain prairies and other fire-dependent community types. Degraded lakeplain oak openings that have been long deprived of fire often contain a heavy overstory and understory of shade-tolerant species such as red maple and green ash, which can be removed by mechanical thinning, herbiciding, or girdling. Restored sites can be maintained by periodic prescribed fires and may require investment in native plant seeding where seed and plant banks are inadequate.

Monitoring and control efforts to detect and remove invasive species are critical to the success of restoration projects. Invasive species that threaten the diversity and community structure of either the dry beach ridges or wet swales of lakeplain oak openings include spotted knapweed (*Centaurea maculosa*), common St. John's-wort (*Hypericum perforatum*), black swallow-wort (*Vincetoxicum nigrum*), white swallow-wort (*V. rossicum*), Japanese knotweed (*Polygonum cuspidatum*), Kentucky bluegrass (*Poa pratensis*), Canada bluegrass (*P. compressa*), ox-eye daisy (*Chrysanthemum leucanthemum*), hawkweeds (*Hieracium* spp.), sheep sorrel (*Rumex acetosella*), hoary alyssum (*Berteroa incana*), reed (*Phragmites australis*), reed canary grass (*Phalaris arundinacea*), narrow-leaved cat-tail (*Typha angustifolia*), hybrid cat-tail (*Typha xglauca*), purple loosestrife (*Lythrum salicaria*), Oriental bittersweet (*Celastrus orbiculatus*), common buckthorn (*Rhamnus cathartica*), glossy buckthorn (*R. frangula*), autumn olive (*Elaeagnus umbellata*), Eurasian honeysuckles (*Lonicera morrowii*, *L. japonica*, *L. maackii*, *L. sempervirens*, *L. tatarica*, *L. xbella*, and *L. xylosteum*), and multiflora rose (*Rosa multiflora*).

Native Americans utilized dune ridges on the lakeplain for settlements and trails, and it is quite likely that fires resulting from this use periodically spread to adjacent oak openings and prairies.

Most lakeplain oak openings were cleared for agriculture, and either residential or industrial development. Within the few remnant lakeplain oak openings, alterations of groundwater hydrology and fire suppression have resulted in increased encroachment by woody species and succession to shrub and forest communities. Absence of fire in lakeplain oak openings causes decreased herb diversity, increased canopy and subcanopy cover, invasion of fire-intolerant species, and ultimately the formation of a closed-canopy oak community, often within 20 to 40 years. The hydrologic regime of the lakeplain and lakeplain oak openings has been drastically altered. Many lakeplain landscapes are artificially ditched and drained. Beaver activity has been eliminated in these systems for nearly 200 years.

Variation

There are two prominent forms of lakeplain oak openings that occur interspersed through ridge and swale topography. In both types, oaks dominate the tree canopy layer, and grasses and sedges make up the majority of the ground layer. The dry-mesic type occurs on droughty beach ridges and is typically dominated by black oak and white oak. The wet-mesic type, found on flat, poorly drained areas, is dominated by bur oak, pin oak, and swamp white oak, with a ground layer similar to lakeplain wet prairie and lakeplain wet-mesic prairie.

Similar Natural Communities

Lakeplain wet prairie, lakeplain wet-mesic prairie, wet-mesic sand prairie, mesic sand prairie, wet-mesic flatwoods, bur oak plains, oak openings, dry-mesic southern forest, dry sand prairie, dry southern forest, oak barrens, oak-pine barrens, and wooded dune and swale complex.

Relevant Literature

- Cohen, J.G. 2001. Natural community abstract for lakeplain oak openings. Michigan Natural Features Inventory, Lansing, MI. 9 pp.
- Faber-Langendoen, D., and P.F. Maycock. 1987. Composition and soil environment analysis of prairies on Walpole Island, southwestern Ontario. *Canadian Journal of Botany* 65: 2410-2419.
- Hayes, B.N. 1964. An ecological study of wet prairie on Harsens Island, Michigan. *Michigan Botanist* 3: 71-82.
- Nuzzo, V. 1986. Extent and status of Midwest oak savanna: Presettlement and 1985. *Natural Areas Journal* 6(2): 6-36.

For a full list of references used to create this description, please refer to the natural community abstract for lakeplain oak openings.

FOREST COMMUNITIES

Dry Northern Forest

Global/State Rank: G3?/S3

Overview

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 (*Pinus banksiana*) or jack pine and hardwoods, and the other dominated by red pine (*P. resinosa*). Prior to European settlement, dry northern forest typically originated in the wake of catastrophic fire. Frequent, low-intensity ground fires maintained red pine systems by removing competing hardwoods.

Landscape Context

Dry northern forest occurs principally on sandy glacial outwash and sandy glacial lakeplains, and also commonly on sand ridges within peatlands on glacial outwash or glacial lakeplains.

Soils

Soils are coarse-textured, well-sorted, excessively drained dry sands with low amounts of organic matter and low water-holding capacity. The droughty soils are extremely acid to very strongly acid with low nutrient content and high frost proclivity.

Natural Processes

The natural disturbance regime of dry northern forest is characterized by infrequent catastrophic fire, with estimated return intervals ranging from 10 to 80 years in jack pine forests and 120 to 300 years in red pine forests. Red pine-dominated forests also experienced frequent, low-intensity, stand-perpetuating surface fires, with estimated return intervals ranging from 5 to 20 years. Windthrow, insect epidemics, and growing-season frosts are also important disturbance factors.

Vegetation

The overstory of dry northern forest is dominated by jack pine (*Pinus banksiana*) or red pine (*P. resinosa*). Northern pin oak (*Quercus ellipsoidalis*) usually accompanies jack pine in the canopy; big-toothed aspen (*Populus grandidentata*), red maple (*Acer rubrum*), and paper birch (*Betula papyrifera*) are typical canopy associates in stands of red pine. Red pine, white pine (*P. strobus*), and balsam fir (*Abies balsamea*) often occur in the subcanopy. Low sweet blueberry (*Vaccinium angustifolium*), bush honeysuckle (*Diervilla lonicera*), and sweetfern (*Comptonia peregrina*) are typically prevalent in shrub layer. The ground layer is dominated by Pennsylvania sedge (*Carex pensylvanica*) and bracken fern (*Pteridium aquilinum*). Other typical species include serviceberry (*Amelanchier spicata*), spreading dogbane (*Apocynum androsaemifolium*), bearberry (*Arctostaphylos uva-ursi*), pipsissewa (*Chimaphila umbellata*), poverty grass (*Danthonia spicata*), hair grass (*Deschampsia flexuosa*), trailing arbutus (*Epigaea repens*), wintergreen (*Gaultheria procumbens*), huckleberry (*Gaylussacia baccata*), rattlesnake weed (*Hieracium venosum*), cow-wheat (*Melampyrum lineare*), rice grass (*Oryzopsis pungens*), sand cherry (*Prunus pumila*), northern dewberry (*Rubus flagellaris*), starflower (*Trientalis borealis*), and Canada blueberry (*Vaccinium myrtilloides*). Important bryophytes include lichens (*Cladina rangifera* and *C. mitis*) and mosses (*Dicranum* spp., *Hypnum* spp. and *Pleurozium schreberi*).

Noteworthy Animals

Kirtland's warbler (*Dendroica kirtlandii*, federal/state endangered) depends on large blocks of young jack pine for nesting and breeding.

Rare Plants

Antennaria parvifolia (pussy-toes, state special concern)

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)

Prunus alleghaniensis var. *davisii* (Alleghany plum, state special concern)

Pterospora andromedeae (pine-drops, state threatened)

Rare Animals

Accipiter gentilis (northern goshawk, state special concern)

Appalachia arcana (secretive locust, state special concern)

Atrytonopsis hianna (dusted skipper, state special concern)

Dendroica discolor (prairie warbler, state endangered)

Dendroica kirtlandii (Kirtland's warbler, federal/state endangered)

Falco columbarius (merlin, state threatened)

Haliaeetus leucocephalus (bald eagle, state special concern)

Incisalia henrici (Henry's elfin, state threatened)

Incisalia irus (frosted elfin, state threatened)

Merolonche dolli (Doll's merolonche, state special concern)

Pandion haliaetus (osprey, state special concern)

Picoides arcticus (black-backed woodpecker, state special concern)

Pyrgus wyandot (grizzled skipper, state special concern)

Biodiversity Management Considerations

Fire suppression can result in failure of pine to regenerate, invasion by shade-tolerant species, and eventual conversion of dry northern forest to more mesic forest types. Naturally regenerated, mature red pine-dominated forest is a rare forest type in the Great Lakes region. In fire-suppressed landscapes, natural red pine stands can be maintained by prescribed surface fires.

Numerous invasive plants are common in the ground layer of openings within dry northern forests, especially where fire has been excluded. Prevalent non-native plants include spotted knapweed (*Centaurea maculosa*), common St. John's-wort (*Hypericum perforatum*), hawkweeds (*Hieracium* spp.), sheep sorrel (*Rumex acetosella*), Canada bluegrass (*Poa compressa*), Kentucky bluegrass (*P. pratensis*), timothy (*Phleum pratense*), and common mullein (*Verbascum thapsus*). Efforts to monitor and control invasive species are critical for protecting biodiversity.

Logging and slash fires likely resulted in an increase in acreage of mature dry northern forest dominated by jack pine and a decrease in red pine-dominated systems. Fire suppression has resulted in conversion of dry northern forest to more mesic forest types and also the conversion of pine barrens to dry northern forest. Many sites formerly occupied by natural pine forest were planted to pines in the 1920s and 1930s and these have been maintained as plantations. Bracken-grassland is likely derived from disturbed dry and dry-mesic northern forests. Natural openings in dry northern forest exist in small depressions (i.e., frost pockets) due to microclimatic effects (primarily cold air drainage), but logging and slash fires produced the extensive "stump prairies" dominated by lichens, poverty grass, bracken fern, and invasive plants, which typically include

bluegrasses, hawkweeds, sheep sorrel, timothy, and common mullein. Very slow invasion of these sites by choke cherry (*Prunus virginiana*), black cherry (*Prunus serotina*), quaking aspen (*Populus tremuloides*), and paper birch (*Betula papyrifera*) is taking place.

Variation

Major vegetative variants include jack pine forest, jack pine–hardwood forest, and red pine forest. Jack pine or mixed jack pine forest occurs on expanses of dry sandy outwash plains, especially in the northern Lower Peninsula, and tend to be broad and extensive in area. Red pine–dominated systems occur on inland dune ridges and also on high elevation ice-contact island ridges within jack pine– or jack pine–red pine–dominated outwash plains and tend to be narrow and linear in shape, like the landforms they occupy. Jack pine–northern pin oak forest typically occurs adjacent to pine barrens.

Similar Natural Communities

Pine barrens, dry-mesic northern forest, oak-pine barrens, and wooded dune and swale complex.

Relevant Literature

- Cayford, J.H. 1970. The role of fire in the ecology and silviculture of jack pine. Proceedings of the Annual Tall Timbers Fire Ecology Conference 10: 221-244.
- Cohen, J.G. 2002. Natural community abstract for dry northern forest. Michigan Natural Features Inventory, Lansing, MI. 14 pp.
- Heinselman, M.L. 1973. Fire in the virgin forests of the Boundary Waters Canoe Area, Minnesota. Journal of Quaternary Research 3: 329-382.
- Simard, A.J., and R.W. Blank. 1982. Fire history of a Michigan jack pine forest. Michigan Academician 15: 59-71.
- Stocks, B.J. 1989. Fire behavior in mature jack pine. Canadian Journal of Forest Research 19: 783-790.
- Van Wagner, C.E. 1970. Fire and red pine. Proceedings of the Annual Tall Timbers Fire Ecology Conference 10: 211-219.
- Whitney, G.C. 1986. Relation of Michigan's presettlement pine forest to substrate and disturbance history. Ecology 67(6): 1548-1559.

For a full list of references used to create this description, please refer to the natural community abstract for dry northern forest.

Dry-mesic Northern Forest

Global/State Rank: G4/S3

Overview

Dry-mesic northern forest is a pine or pine-hardwood forest type of generally dry-mesic sites located mostly north of the transition zone. The community historically originated in the wake of catastrophic fire and was maintained by frequent, low-intensity ground fires.

Landscape Context

Dry mesic northern forest occurs principally on sandy glacial outwash, sandy glacial lakeplains, and less often on inland dune ridges, coarse-textured moraines, and thin glacial drift over bedrock.

Soils

Sand or loamy sand soils are extremely acid to very strongly acid and coarse- to medium-textured. A surface layer of mor humus is normally present due to the accumulation of pine needles.

Natural Processes

The natural disturbance regime of dry-mesic northern forest is characterized by both infrequent, catastrophic fire, with return intervals estimated to range from 120 to 300 years, and frequent, low-intensity surface fires, with return intervals estimated from 5 to 20 years. Additional important natural disturbance factors include windthrow and insect epidemics.

Vegetation

White pine (*Pinus strobus*) is nearly always a dominant or important canopy species within this forest type, often forming a supercanopy above other tree species. Red pine (*Pinus resinosa*) and hemlock (*Tsuga canadensis*) are frequently present and occasionally codominant with white pine in the canopy or supercanopy. Hardwood associates include white oak (*Quercus alba*), black oak (*Q. velutina*), red oak (*Q. rubra*), and red maple (*Acer rubrum*). Paper birch (*Betula papyrifera*), aspen (*Populus tremuloides* and *P. grandidentata*), and balsam poplar (*P. balsamifera*) are also common in the overstory. Balsam fir (*Abies balsamea*) and white spruce (*Picea glauca*) are often present in the subcanopy, especially in fire-suppressed systems. Bracken fern (*Pteridium aquilinum*) often dominates the ground layer. Characteristic species of the shrub layer include serviceberries (*Amelanchier* spp.), beaked hazelnut (*Corylus cornuta*), bush honeysuckle (*Diervilla lonicera*), huckleberry (*Gaylussacia baccata*), witch-hazel (*Hamamelis virginiana*), American fly honeysuckle (*Lonicera canadensis*), choke cherry (*Prunus virginiana*), and blueberries (*Vaccinium* spp.). Typical ground layer species include wild sarsaparilla (*Aralia nudicaulis*), pipsissewa (*Chimaphila umbellata*), goldthread (*Coptis trifolia*), bunchberry (*Cornus canadensis*), trailing arbutus (*Epigaea repens*), wintergreen (*Gaultheria procumbens*), twin flower (*Linnaea borealis*), partridge berry (*Mitchella repens*), gay wings (*Polygala paucifolia*), and starflower (*Trientalis borealis*). The presence of chlorophyll-free, parasitic and saprophytic seed plants such as Indian pipes (*Monotropa* spp.), coral root orchids (*Corallorhiza* spp.), and pine-drops (*Pterospora andromedea*, state threatened) is a common feature of dry-mesic northern forest.

Noteworthy Animals

This community provides summer nesting habitat for many neotropical migrants, especially interior forest obligates such as black-throated blue warbler (*Dendroica caerulescens*), black-throated green warbler (*Dendroica virens*), scarlet tanager (*Piranga olivacea*), and ovenbird (*Seiurus aurocapillus*). Where the community occurred in proximity to streams and lakes, beaver (*Castor canadensis*) likely played a role in reducing mesophytic invasion of the subcanopy and understory, selectively removing shade-tolerant species.

Rare Plants

Arnica cordifolia (heart-leaved arnica, state endangered)

Clematis occidentalis (purple clematis, state threatened)

Dalibarda repens (false violet, state threatened)

Erigeron acris (fleabane, state threatened)

Oplopanax horridus (devil's-club, state threatened)

Osmorhiza depauperata (sweet cicely, state threatened)

Pterospora andromeda (pine-drops, state threatened)

Senecio indecorus (rayless mountain ragwort, state threatened)

Rare Animals

Accipiter gentilis (northern goshawk, state special concern)

Falco columbarius (merlin, state threatened)

Haliaeetus leucocephalus (bald eagle, state special concern)

Pandion haliaetus (osprey, state special concern)

Picoides arcticus (black-backed woodpecker, state special concern)

Biodiversity Management Considerations

Fire suppression can result in the failure of pines to regenerate, invasion and maturation of shade-tolerant tree species, and eventual conversion to mesic forest. Prescribed fire management can be used to promote pine establishment and regeneration. Where fire is not feasible, effects of surface fire can be mimicked by thinning, mechanically scarifying the soils, and girdling and herbiciding competing vegetation. Under-planting pine seedlings can be used to reestablish pines where a natural seed source is unavailable.

Monitoring and control efforts to detect and remove invasive species are critical to the long-term viability of dry-mesic northern forest. By outcompeting native species, invasives alter vegetation structure, reduce species diversity, and disrupt ecological processes. Invasive plants that may have potential to threaten diversity and alter community structure in dry-mesic northern forest include garlic mustard (*Alliaria petiolata*), spotted knapweed (*Centaurea maculosa*), common St. John's-wort (*Hypericum perforatum*), hawkweeds (*Hieracium* spp.), sheep sorrel (*Rumex acetosella*), Canada bluegrass (*Poa compressa*), Kentucky bluegrass (*P. pratensis*), autumn olive (*Elaeagnus umbellata*), common buckthorn (*Rhamnus cathartica*), Eurasian honeysuckles (*Lonicera morrowii*, *L. japonica*, *L. maackii*, *L. sempervirens*, *L. tatarica*, *L. xbella*, and *L. xylosteum*), and multiflora rose (*Rosa multiflora*).

Variation

Species composition and community structure of dry-mesic northern forest vary regionally and are strongly influenced by historic fire regimes, climatic conditions, landform, soil texture, topography, and landscape context (i.e., proximity to water bodies and fire-resistant or fire-conducting plant communities). White oak-white pine forests are prevalent on areas of sandy outwash plain and lakeplain in far western, central Lower Michigan, both north and south of the climatic tension zone, on areas of sandy outwash plain and lakeplain. White pine-red pine forest

occurs in the northern Lower and Upper Peninsulas on outwash plains, rolling moraines, and inland dune ridges. Sandy, coarse-textured morainal slopes and ridges in northern Lower Michigan support forests of white pine, red pine, and oaks. Moderately drained sand lakeplains and outwash from Saginaw Bay through the Upper Peninsula historically supported white pine forest and hemlock-white pine forest. Thin glacial drift over bedrock in the western Upper Peninsula supports forests dominated by white pine, red pine, and red oak. Dry-mesic northern forests found on inland dune systems tend to be narrow and linear, like the dunes they occupy. Forests surrounding lakes and alongside rivers and streams are also linear. Historically, the most extensive dry-mesic northern forests occurred on broad areas of outwash and lakeplain.

Similar Natural Communities

Dry northern forest, hardwood-conifer swamp, mesic northern forest, northern bald, granite bedrock glade, volcanic bedrock glade, oak-pine barrens, and wooded dune and swale complex.

Relevant Literature

- Brubaker, L.B. 1975. Postglacial forest patterns associated with till and outwash in northcentral Upper Michigan. *Quaternary Research* 5: 499-527.
- Cohen, J.G. 2002. Natural community abstract for dry-mesic northern forest. Michigan Natural Features Inventory, Lansing, MI. 12 pp.
- Heinselman, M.L. 1973. Fire in the virgin forests of the Boundary Waters Canoe Area, Minnesota. *Journal of Quaternary Research* 3: 329-382.
- McRae, D.J., T.J. Lynham, and R.J. Frech. 1994. Understory prescribed burning in red pine and white pine. *Forestry Chronicle* 70(4): 395-401.
- Quinby, P.A. 1991. Self-replacement in old-growth white pine forests of Temagami, Ontario. *Forest Ecology and Management* 41: 95-109.
- Stearns, F. 1950. The composition of a remnant of white pine forest in the Lake States. *Ecology* 31(2): 290-292.
- Van Wagner, C.E. 1970. Fire and red pine. *Proceedings of the Annual Tall Timbers Fire Ecology Conference* 10: 211-219.
- Whitney, G.C. 1986. Relation of Michigan's presettlement pine forest to substrate and disturbance history. *Ecology* 67(6): 1548-1559.

For a full list of references used to create this description, please refer to the natural community abstract for dry-mesic northern forest.

Mesic Northern Forest

Global/State Rank: G4/S3

Overview

Mesic northern forest is a forest type of moist to dry-mesic sites lying mostly north of the climatic tension zone, characterized by the dominance of northern hardwoods, particularly sugar maple (*Acer saccharum*) and American beech (*Fagus grandifolia*). Conifers such as hemlock (*Tsuga canadensis*) and white pine (*Pinus strobus*) are frequently important canopy associates. This community type breaks into two broad classes: northern hardwood forest and hemlock-hardwood forest. It is primarily found on coarse-textured ground and end moraines, and soils are typically loamy sand to sandy loam. The natural disturbance regime is characterized by gap-phase dynamics; frequent, small windthrow gaps allow for the regeneration of the shade-tolerant canopy species. Catastrophic windthrow occurred infrequently with several generations of trees passing between large-scale, severe disturbance events. Historically, mesic northern forest occurred as a matrix system, dominating vast areas of mesic uplands in the Great Lakes region. These forests were multi-generational, with old-growth conditions lasting many centuries.

Landscape Context

Mesic northern forests are found chiefly on coarse-textured ground and end moraines, but are also common on silty/clayey lakeplains, thin glacial till over bedrock, and medium-textured moraines. The community occurs locally on kettle-kame topography, moderately well-drained to well-drained sandy lakeplain, and on north-facing sand dunes as far south as Berrien County in southern Lower Michigan.

Soils

A wide variety of soils support mesic northern forest but most typically it occurs on loamy sand to sandy loam and occasionally on sand, loam, and clay. Soils range widely in pH from extremely acidic to moderately alkaline but are more commonly extremely acid to medium acid.

Natural Processes

The natural disturbance regime is characterized by frequent, small-scale wind disturbance or gap-phase dynamics and infrequent intermediate- and large-scale wind events. Severe low pressure systems are a significant source of small-scale canopy gaps. Catastrophic windthrow, from tornadoes and downbursts, occurs infrequently (estimated return intervals are >1000 years). Catastrophic fire was historically correlated with catastrophic windthrow, especially in hemlock-dominated forests. Due to the long interval between large-scale disturbance events, mesic northern forests tend to be multi-generational, with old-growth conditions lasting several centuries. Ice storms affecting hundreds to thousands of acres act to thin canopy cover and promote tree regeneration. Historically, where mesic northern forest bordered fire-dependent pine and oak-pine systems, low-intensity surface fires may have infrequently burned portions of the ground layer, exposing patches of mineral soil and thereby promoting regeneration of small-seeded conifers.

Vegetation

Dominant tree species of mesic northern forest include sugar maple, American beech, and hemlock. While sugar maple most frequently dominates the community throughout Michigan, American beech is excluded from the western Upper Peninsula by extremely low winter temperatures. Other important components of the canopy include yellow birch (*Betula*

alleghaniensis), white ash (*Fraxinus americana*), basswood (*Tilia americana*), red oak (*Quercus rubra*), northern white-cedar (*Thuja occidentalis*), and white pine, which can attain supercanopy status. In sugar maple stands, basswood or American beech are often important, along with yellow birch, white ash, and red oak. The proportion of conifers and hardwoods other than sugar maple often increases when groundwater or bedrock influences the rooting zone. In stands where hemlock predominates or is accompanied by sugar maple, canopy associates may include: yellow birch, red maple (*Acer rubrum*), American beech, paper birch (*Betula papyrifera*), red oak, and white pine. Forests dominated by sugar maple and northern white-cedar are found in dunes or over calcareous bedrock.

Typical subcanopy species include balsam fir (*Abies balsamea*), ironwood (*Ostrya virginiana*), and American elm (*Ulmus americana*). American elm was a canopy dominant before the introduction of Dutch elm disease. The shrub layer is characterized by striped maple (*Acer pensylvanicum*), mountain maple (*A. spicatum*), alternate-leaved dogwood (*Cornus alternifolia*), beaked hazelnut (*Corylus cornuta*), leatherwood (*Dirca palustris*), American fly honeysuckle (*Lonicera canadensis*), prickly gooseberry (*Ribes cynosbati*), red elderberry (*Sambucus racemosa*), and maple-leaved arrow-wood (*Viburnum acerifolium*). Prevalent species in the ground layer, representing a broad range of moisture conditions, include doll's eyes (*Actaea pachypoda*), red baneberry (*A. rubra*), maidenhair fern (*Adiantum pedatum*), wild leek (*Allium tricoccum*), wild sarsaparilla (*Aralia nudicaulis*), jack-in-the-pulpit (*Arisaema triphyllum*), rattlesnake fern (*Botrychium virginianum*), pubescent sedge (*Carex hirtifolia*), plantain-leaf sedge (*C. plantaginea*), blue cohosh (*Caulophyllum thalictroides*), bunchberry (*Cornus canadensis*), spinulose woodfern (*Dryopteris carthusiana*), fragrant bedstraw (*Galium triflorum*), hairy sweet cicely (*Osmorhiza claytonii*), downy Solomon seal (*Polygonatum pubescens*), false Solomon's seal (*Smilacina racemosa*), rose twisted stalk (*Streptopus roseus*), large-flowered bellwort (*Uvularia grandiflora*), and trilliums (*Trillium* spp.).

Noteworthy Animals

Large contiguous tracts of old-growth and mature mesic northern forest provide important habitat for cavity nesters, species of detritus-based food webs, canopy-dwelling species, and interior forest obligates, including numerous neotropical migrants, such as black-throated blue warbler (*Dendroica caerulescens*), black-throated green warbler (*Dendroica virens*), scarlet tanager (*Piranga olivacea*), and ovenbird (*Seiurus aurocapillus*).

Rare Plants

Asplenium rhizophyllum (walking fern, state threatened)
Asplenium scolopendrium var. *americanum* (Hart's-tongue fern, federal threatened and state endangered)
Asplenium trichomanes-ramosum (green spleenwort, state special concern)
Botrychium mormo (goblin moonwort, state threatened)
Carex assiniboinensis (Assiniboia sedge, state threatened)
Carex novae-angliae (New England sedge, state threatened)
Cystopteris laurentiana (Laurentian fragile fern, state special concern)
Cystopteris tennesseensis (Tennessee bladder fern, state threatened)
Dentaria maxima (large toothwort, state threatened)
Disporum hookeri (fairy bells, state endangered)
Dryopteris filix-mas (male fern, state special concern)
Galearis spectabilis (showy orchis, state threatened)
Galium kamtschaticum (bedstraw, state endangered)
Gnaphalium sylvaticum (cudweed, state threatened)
Panax quinquefolius (ginseng, state threatened)

Tipularia discolor (crane-fly orchid, state endangered)
Triphora trianthophora (three-birds orchid, state threatened)
Viola novae-angliae (New England violet, state threatened)

Rare Animals

Accipiter gentilis (northern goshawk, state special concern)
Alces americanus (moose, state special concern)
Buteo lineatus (red-shouldered hawk, state threatened)
Canis lupus (gray wolf, federal endangered and state threatened)
Guppya sterkii (Sterki's granule, state endangered)
Microtus pinetorum (woodland vole, state special concern)

Biodiversity Management Considerations

Biodiversity management requires a multi-scale approach and can be realized by taking the following actions. Emulate natural disturbance regimes and manage landscapes within the historical range of variability. Leave large tracts (especially old-growth and late-successional forest) unharvested and allow natural processes to operate unhindered. Increase the acreage of mature mesic northern forest by allowing early-successional forest to convert to late-successional forest. Reduce forest fragmentation by decreasing forest harvest levels, halting the creation of wildlife openings in forested landscapes, closing redundant forest roads, limiting the creation of new roads, and allowing wildlife openings and old field to revert to forest. Extend rotation periods of managed forests beyond 100 years to allow for the development of late-successional characteristics and species. Reduce high deer densities to levels at which herbivory no longer limits tree recruitment and reduces floral diversity. Maximize forest continuity by retaining large-diameter snags, coarse woody debris, and old, living trees. Where large-diameter snags and coarse woody debris are lacking, increase structural heterogeneity by creating snags through girdling, felling trees, and if necessary, skidding in large-diameter, long-lived, slowly decaying conifer species. Retain and promote hemlock, white pine, and northern white-cedar where they persist. Maintain and create suitable sites for conifer establishment by retention of large-diameter nurse logs and, in fire-prone landscapes, exposure of mineral soil through infrequent, low-intensity prescribed surface fires. Erect deer exclosures to protect hemlock, white pine, and cedar regeneration. Where hemlock and white pine seed sources are absent, underplant saplings. Mimic gap-phase dynamics and promote dead-tree dynamics when harvesting. Maintain genetic legacy of managed forests by retaining old trees and promoting natural regeneration.

Monitoring and control efforts to detect and remove invasive species before they become widespread are critically important for long-term viability of mesic northern forest. By outcompeting native species, invasive plants alter vegetation structure, reduce species diversity, and disrupt ecological processes. Invasive plant species that threaten the diversity and community structure in mesic northern forest include garlic mustard (*Alliaria petiolata*), Dame's rocket (*Hesperis matronalis*), Eurasian honeysuckles (*Lonicera morrowii*, *L. sempervirens*, *L. tatarica*, *L. xbella*, and *L. xylosteum*), Japanese barberry (*Berberis thunbergii*), common buckthorn (*Rhamnus cathartica*), glossy buckthorn (*R. frangula*), multiflora rose (*Rosa multiflora*), and Norway maple (*Acer platanoides*). This community type may be vulnerable to pests, including the hemlock woolly adelgid (*Adelges tsugae*), which can cause significant hemlock mortality if it spreads throughout Michigan, the emerald ash borer (*Agilus planipennis*), which has already decimated ash populations in southeastern Lower Michigan, and the beech scale insect (*Cryptococcus fagisuga*), which renders beech trees susceptible to killing attacks by fungi of the genus *Nectria*.

Intensive and pervasive anthropogenic disturbance during the past 150 years has altered the extent, landscape pattern, natural processes, structure, and species composition of mesic northern forest. Mesic northern forest, especially old-growth and late-successional forest, has been drastically reduced in acreage. This matrix community has become fragmented, with most old-growth and late-successional stands now persisting as remnant patches enmeshed in a matrix of agricultural lands, early-successional forest, and young northern hardwoods. Short-rotation timber management has replaced gap-phase dynamics as the dominant disturbance factor affecting structure and species composition. Structural alterations include the reduction of large-diameter trees, snags, and coarse woody debris. Hemlock and white pine have declined in importance within these systems. Fire suppression in nearby fire-prone systems has probably contributed to the lack of conifer recruitment in some sites as has a lack of suitable substrates for seedling establishment such as large-diameter nurse logs. Chronically high deer densities have further limited tree recruitment and altered floral composition and structure.

Variation

Mesic northern forest is a broadly defined community type with numerous regional, physiographic, and edaphic variations. Two broad classes are recognized, hardwood-dominated forest and hemlock-hardwood forest.

In the northern Lower Peninsula and in the eastern Upper Peninsula, sugar maple and beech commonly occur as codominants, frequently thriving on heavy-textured soils such as silt loam and clay loam. Beech is absent from most systems in the western Upper Peninsula, likely due to the extreme minimum winter temperatures, shorter growing season, and increased dryness. Basswood, characteristic of nutrient-rich sites, is most prevalent in mixed-hardwood stands in the western Upper Peninsula and most closely associated with sugar maple.

Hemlock-hardwood forests may include a variety of conifers and northern hardwoods, which vary in relative dominance depending on climate, landform, soils, aspect, drainage, and proximity to inland lakes or the Great Lakes. Some of dominant canopy trees in these mixed forests include hemlock, white pine, northern white-cedar, yellow birch, American beech, and sugar maple. Hemlock, white pine, northern white-cedar, and yellow birch increase in importance in areas with modified climate (areas near the Great Lakes) or microclimate (adjacent to inland lakes and rivers, in ravines, and slopes with north-to-east aspects) or poor drainage (poorly drained lakeplains). Extensive tracts of sugar maple and northern white-cedar were located in dunes or over calcareous bedrock and today are found locally in dunes along the Great Lakes shoreline, on Great Lakes islands, and on the drumlin fields of Menominee County. White pine mixed with northern hardwoods reached its greatest abundance on drier southeast-facing slopes of well-drained moraines and ice-contact features.

Similar Natural Communities

Mesic southern forest, dry-mesic northern forest, and hardwood-conifer swamp.

Relevant Literature

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- Woods, K.D. 2004. Intermediate disturbance in a late-successional hemlock-northern hardwood forest. *Journal of Ecology* 92: 464-476.
- Zhang, Q., K.S. Pregitzer, and D.D. Reed. 2000. Historical changes in the forests of the Luce District of the Upper Peninsula of Michigan. *American Midland Naturalist* 143(1): 94-110.

For a full list of references used to create this description, please refer to the natural community abstract for mesic northern forest.

Dry Southern Forest

Global/State Rank: G4/S3

Overview

Dry southern forest is a fire-dependent, oak-dominated forest type on dry sites lying mostly south of the climatic tension zone in southern Lower Michigan. Frequent fires maintain semi-open conditions, promoting oak regeneration and ground and shrub layer diversity.

Landscape Context

The community occurs principally on glacial outwash, and less frequently on sand dunes, sandy glacial lakeplains, and coarse-textured moraines. Dry southern forest typically occurs in conjunction with other fire-dependent upland and wetland communities such as dry-mesic southern forest, oak barrens, dry sand prairie, coastal plain marsh, southern wet meadow, and prairie fen.

Soils

The soils of dry southern forest are infertile, well-drained sand, loamy sand, or sandy loam with medium to strongly acid pH and low water-retaining capacity.

Natural Processes

Fire, windthrow, and insect outbreaks and pathogens associated with oak defoliation and decline are the prevalent natural disturbance factors influencing dry southern forest. In addition, low-productivity droughty soils also play a significant role in structuring the community. Historically, frequent low-intensity surface fires generated conditions suitable for sustaining advanced oak regeneration and helped keep oak pathogens and invertebrate acorn predators at low levels. Tree density in circa 1800 oak forests was likely lower than that observed today under conditions of fire suppression, and helped limit root-grafting and the spread of several oak pathogens. Frequent small-scale wind disturbance or gap-phase dynamics allows for growth of suppressed oak saplings and canopy ascension of understory oaks. Prolonged periods of fire suppression in oak barrens can result in succession to closed-canopy, dry southern forest and likely accounts for the existence of many oak forests observed today.

Vegetation

The canopy layer generally is dominated or codominated by black oak (*Quercus velutina*) and white oak (*Q. alba*). Prevalent canopy associates include pignut hickory (*Carya glabra*), red maple (*Acer rubrum*), black cherry (*Prunus serotina*), and sassafras (*Sassafras albidum*). Northern pin oak (*Q. ellipsoidalis*) is present on the driest sites close to the tension zone. Prevalent species of the subcanopy layer include flowering dogwood (*Cornus florida*), American hazelnut (*Corylus americana*), cherries (*Prunus* spp.), and sassafras. Characteristic shrubs include serviceberries (*Amelanchier* spp.), New Jersey tea (*Ceanothus americanus*), low sweet blueberry (*Vaccinium angustifolium*), Canada blueberry (*Vaccinium myrtilloides*), gray dogwood (*Cornus foemina*), American hazelnut (*Corylus americana*), hawthorns (*Crataegus* spp.), huckleberry (*Gaylussacia baccata*), witch-hazel (*Hamamelis virginiana*), choke cherry (*Prunus virginiana*), and blackberries (*Rubus* spp.). Typical herbaceous species include hog-peanut (*Amphicarpaea bracteata*), wild geranium (*Geranium maculatum*), beggars lice (*Hackelia virginiana*), woodland sunflower (*Helianthus divaricatus*), whorled loosestrife (*Lysimachia quadrifolia*), false Solomon's seal (*Smilacina racemosa*), wintergreen (*Gaultheria procumbens*), and summer grape (*Vitis aestivalis*).

Noteworthy Animals

The now extinct passenger pigeon (*Ectopistes migratorius*) was likely a keystone species in oak ecosystems, roosting in oak forests by the thousands.

Rare Plants

Angelica venenosa (hairy angelica, state special concern)
Aster drummondii (Drummond's aster, state threatened)
Baptisia leucophaea (cream wild indigo, state endangered)
Celtis tenuifolia (dwarf hackberry, state special concern)
Dennstaedtia punctilobula (hay-scented fern, state threatened)
Geum virginianum (pale avens, state special concern)
Houstonia caerulea (bluets, presumed extirpated from Michigan)

Rare Animals

Pantherophis spiloides (gray ratsnake, state special concern)
Sistrurus c. catenatus (eastern massasauga, federal candidate species and state special concern)
Terrapene c. carolina (eastern box turtle, state special concern)

Biodiversity Management Considerations

Fire is the single most significant factor in preserving oak ecosystems. The use of prescribed fire is an imperative management tool for promoting oak regeneration and deterring the succession of shade-tolerant species and encroachment by invasive shrubs. Fire management should be orchestrated in conjunction with management of adjacent fire-dependent communities such as oak barrens, dry sand prairie, prairie fen, and coastal plain marsh. Many dry southern forests represent degraded oak barrens that have been long deprived of fire. Open canopy conditions can be restored by mechanical thinning or girdling of understory and overstory trees. Restored sites can be maintained by periodic prescribed fire and may require investment in native plant seeding where seed and plant banks are inadequate.

Monitoring and control efforts to detect and remove invasive species are critical to the long-term viability of dry southern forest. Invasive species that threaten the diversity and community structure include garlic mustard (*Alliaria petiolata*), black swallow-wort (*Vincetoxicum nigrum*), white swallow-wort (*V. rossicum*), Oriental bittersweet (*Celastrus orbiculatus*), common buckthorn (*Rhamnus cathartica*), autumn olive (*Elaeagnus umbellata*), Eurasian honeysuckles (*Lonicera morrowii*, *L. japonica*, *L. maackii*, *L. sempervirens*, *L. tatarica*, *L. xbella*, and *L. xylosteum*), and multiflora rose (*Rosa multiflora*).

Variation

Toward the transition zone, white pine (*Pinus strobus*) becomes a constant canopy associate.

Similar Natural Communities

Oak barrens, oak-pine barrens, dry-mesic southern forest, dry northern forest, and dry-mesic northern forest.

Relevant Literature

Abrams, M.D. 1992. Fire and the development of oak forests. *BioScience* 42(5): 346-353.
Anderson, M.D., and L.E. Brown. 1983. Comparative effects of fire on trees in a Midwestern savannah and an adjacent forest. *Bulletin of the Torrey Botanical Club* 119(1): 19-28.
Brewer, L.G., T.W. Hodler, and H.A. Raup. 1984. Presettlement vegetation of southwestern Michigan. *Michigan Botanist* 23(4): 153-156.

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Dry-mesic Southern Forest

Global/State Rank: G4/S3

Overview

Dry-mesic southern forest is a fire-dependent, oak or oak-hickory forest type on generally dry-mesic sites found south of the climatic tension zone in southern Lower Michigan. Frequent fires maintain semi-open conditions, promoting oak regeneration and ground and shrub layer diversity.

Landscape Context

This natural community occurs principally on glacial outwash, coarse-textured moraines, sandy glacial lakeplains, kettle-kame topography, and sand dunes.

Soils

Soils are typically sandy loam or loam and slightly acid to neutral in pH.

Natural Processes

Fire, windthrow, and insect outbreaks and pathogens associated with oak defoliation and decline are the prevalent natural disturbance factors influencing dry-mesic southern forest. Historically, frequent, low-intensity surface fires generated conditions suitable for sustaining advanced oak regeneration and helped keep oak pathogens and invertebrate acorn predators at low levels. Tree density in circa 1800 oak forests was likely lower than that observed today under conditions of fire suppression, and helped limit root-grafting and the spread of several oak pathogens. Frequent small-scale wind disturbance or gap-phase dynamics allows for growth of suppressed oak saplings and canopy ascension of understory oaks. Prolonged periods of fire suppression in oak openings can result in the succession to closed-canopy dry-mesic southern forest and likely accounts for the existence of many oak forests observed today.

Vegetation

The canopy layer generally is dominated or codominated by white oak (*Quercus alba*) and black oak (*Quercus velutina*), with white oak being the more frequent dominant. Red oak (*Q. rubra*) can occur as a canopy codominant, especially where soils and topographic position favor less droughty conditions such as north- to east-facing slopes and footslopes. Hickories such as pignut hickory (*Carya glabra*), shagbark hickory (*C. ovata*), and bitternut hickory (*C. cordiformis*) are often canopy codominants. Prevalent canopy associates may include red maple (*Acer rubrum*), white ash (*Fraxinus americana*), black cherry (*Prunus serotina*), scarlet oak (*Quercus coccinea*), basswood (*Tilia americana*), and sassafras (*Sassafras albidum*). Prevalent species of the subcanopy include red maple, hickories, alternate-leaved dogwood (*Cornus alternifolia*), flowering dogwood (*Cornus florida*), ironwood (*Ostrya virginiana*), cherries (*Prunus* spp.), and sassafras. Characteristic shrubs include serviceberries (*Amelanchier* spp.), witch-hazel (*Hamamelis virginiana*), and choke cherry (*Prunus virginiana*). In fire-suppressed systems, mesophytic trees and shrubs are often dominant in the subcanopy and shrub layers. Typical herbaceous species include doll's eyes (*Actaea pachypoda*), hog-peanut (*Amphicarpaea bracteata*), jack-in-the-pulpit (*Arisaema triphyllum*), bearded shorthusk (*Brachyelytrum erectum*), hairy woodland brome (*Bromus pubescens*), white bear sedge (*Carex albursina*), rosy sedge (*C. convoluta*), enchanter's nightshade (*Circaea lutetiana*), spotted coral-root (*Corallorhiza maculata*), pointed-leaf tick-trefoil (*Desmodium glutinosum*), naked-flower tick-trefoil (*D. nudiflorum*), fragrant bedstraw (*Galium triflorum*), black snakeroot (*Sanicula marilandica*),

bristly greenbrier (*Smilax tamnoides*), large-flowered bellwort (*Uvularia grandiflora*), and downy yellow violet (*Viola pubescens*).

Noteworthy Animals

The now extinct passenger pigeon (*Ectopistes migratorius*) was likely a keystone species in oak ecosystems, roosting in oak forests by the thousands.

Rare Plants

Agrimonia rostellata (beaked agrimony, state threatened)
Arabis missouriensis var. *deamii* (Missouri rock-cress, state special concern)
Aristolochia serpentaria (Virginia snakeroot, state threatened)
Baptisia leucophaea (cream wild indigo, state endangered)
Castanea dentata (American chestnut, state endangered)
Dennstaedtia punctilobula (hay-scented fern, state threatened)
Eupatorium sessilifolium (upland boneset, state threatened)
Geum virginianum (pale avens, state special concern)
Houstonia caerulea (bluets, presumed extirpated from Michigan)
Linum virginianum (Virginia flax, state threatened)
Liparis liliifolia (purple twayblade, state special concern)
Phlox ovata (wideflower phlox, state endangered)
Quercus shumardii (Shumard's oak, state special concern)
Scutellaria elliptica (hairy skullcap, state special concern)
Silene stellata (starry campion, state threatened)
Silene virginica (fire pink, state endangered)
Triphora trianthophora (three-birds orchid, state threatened)
Viburnum prunifolium (black haw, state special concern)

Rare Animals

Ambystoma opacum (marbled salamander, state endangered)
Anguispira kochi (banded globe, state special concern)
Battus philenor (pipevine swallowtail, state special concern)
Buteo lineatus (red-shouldered hawk, state threatened)
Catocala dulciola (quiet underwing, state special concern)
Catocala robinsoni (Robinson's underwing, state special concern)
Dendroica cerulea (cerulean warbler, state threatened)
Emydoidea blandingii (Blanding's turtle, state special concern)
Erynnis baptisiae (wild indigo duskywing, state special concern)
Fixsenia favonius ontario (northern hairstreak, state special concern)
Mesomphix cupreus (copper button, state special concern)
Microtus pinetorum (woodland vole, state special concern)
Neoconocephalus retusus (conehead grasshopper, state special concern)
Nerodia erythrogaster neglecta (copperbelly watersnake, federal threatened and state endangered)
Nicrophorus americanus (American burying beetle, federal/state endangered)
Oecanthus pini (pinetree cricket, federal/state endangered)
Pantherophis spiloides (gray ratsnake, state special concern)
Papaipema cerina (golden borer, state special concern)
Pygarctia spraguei (Sprague's pygarctia, state special concern)
Sistrurus c. catenatus (eastern massasauga, federal candidate species and state special concern)
Terrapene c. carolina (eastern box turtle, state special concern)
Wilsonia citrina (hooded warbler, state special concern)

Xolotrema denotata (velvet wedge, state special concern)

Biodiversity Management Considerations

Fire is the single most significant factor in preserving oak ecosystems. The use of prescribed fire is an imperative management tool for promoting oak regeneration, deterring the succession of shade-tolerant species, and reducing the encroachment by invasive shrubs such as honeysuckles and autumn olive. Fire management should be orchestrated in conjunction with the management of fire-dependent communities such as oak barrens, dry sand prairie, prairie fen, and coastal plain marsh. Many current dry-mesic southern forests are degraded oak openings that have been long deprived of fire. Open canopy conditions can be restored by mechanical thinning or girdling. Restored sites will need to be maintained by periodic prescribed fire and may require investment in native plant seeding where seed and plant banks are inadequate. Herbicide application to stumps is likely necessary where woody invasive species or red maple are well established.

Monitoring and control efforts to detect and remove invasive species are critical to the long-term viability of dry southern forest. Invasive species that threaten the diversity and community structure include garlic mustard (*Alliaria petiolata*), black swallow-wort (*Vincetoxicum nigrum*), white swallow-wort (*V. rossicum*), Oriental bittersweet (*Celastrus orbiculatus*), common buckthorn (*Rhamnus cathartica*), autumn olive (*Elaeagnus umbellata*), Eurasian honeysuckles (*Lonicera morrowii*, *L. japonica*, *L. maackii*, *L. sempervirens*, *L. tatarica*, *L. xbella*, and *L. xylosteum*), multiflora rose (*Rosa multiflora*), and Norway maple (*Acer platanoides*).

Variation

Red oak can occur as a codominant on moister soils. Toward the transition zone, white pine (*Pinus strobus*) becomes a canopy associate.

Similar Natural Communities

Dry southern forest, dry-mesic northern forest, mesic southern forest, and oak openings.

Relevant Literature

- Abrams, M.D. 1992. Fire and the development of oak forests. *BioScience* 42(5): 346-353.
- Brewer, L.G., T.W. Hodler, and H.A. Raup. 1984. Presettlement vegetation of southwestern Michigan. *Michigan Botanist* 23: 153-156.
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- Rodewald, A.D. 2003. Decline of oak forests and implications for forest wildlife conservation. *Natural Areas Journal* 23(4): 368-371.

For a full list of references used to create this description, please refer to the natural community abstract for dry-mesic southern forest.

Mesic Southern Forest

Global/State Rank: G2G3/S3

Overview

Mesic southern forest is an American beech- and sugar maple-dominated forest distributed south of the climatic tension zone and found on flat to rolling topography with predominantly loam soils. The natural disturbance regime is characterized by gap-phase dynamics; frequent, small windthrow gaps allow for the regeneration of shade-tolerant, canopy species. Historically, mesic southern forest occurred as a matrix system, dominating vast areas of rolling to level, loamy uplands of the Great Lakes region. These forests were multi-generational, with old-growth conditions lasting many centuries.

Landscape Context

Mesic southern forest is found principally on medium- or fine-textured ground moraine, medium- or fine-textured end moraine, and on silty/clayey glacial lakeplains. Sand dunes and sandy lakeplains can support these systems where proximity to the Great Lakes modifies the local climate. The community can also occur on ice-contact topography and coarse-textured end moraines, as well as floodplain terraces in a diversity of landforms. Prevalent topographic positions of this community are gentle to moderate slopes and low, level areas with moderate to good drainage.

Soils

The community occurs on a variety of soil types, but loam is the predominant texture. Soils supporting mesic southern forest include sand, sandy loam, loamy sand, loam, silt loam, silty clay loam, clay loam, and clay. Soils are typically well-drained with high water-holding capacity and high nutrient and soil organism content. High soil fertility is maintained by nutrient inputs from the decomposition of deciduous leaves and coarse woody debris. Where American beech is dominant in the canopy, its leaf litter can have a podzolizing effect on the soil, increasing the acidity. Soil pH ranges widely from slightly acidic to moderately alkaline.

Natural Processes

The natural disturbance regime of mesic southern forest is characterized by frequent small-scale wind disturbance or gap-phase dynamics and infrequent, intermediate- to large-scale wind events. Severe low pressure systems generate small-scale canopy gaps, while catastrophic windthrow associated with tornadoes and downbursts can impact large areas. In addition to wind disturbance, glaze or ice storms are a significant source of intermediate disturbance, thinning the canopy and promoting tree regeneration over hundreds to thousands of acres. Approximately 1% of the total area of mesic forest is within recent gap (less than one year old) and the average canopy residence time ranges between 50 and 200 years. Frequent small-scale disturbance events generate a forest mosaic of different-aged patches of gaps of a wide range of sizes; the majority of gaps are between 100 and 400 square meters. Small-scale disturbance events are the primary source of forest turnover. Recruitment of saplings within treefall gaps is typically by shade-tolerant species (primarily sugar maple and American beech) that can exist suppressed beneath the closed canopy for decades. Due to the long interval between large-scale disturbances, mesic southern forests tend to be multi-generational, with old-growth conditions lasting several centuries. Old-growth conditions include a high quantity of dead wood (snags, stumps, and fallen logs) in a diversity of ages, sizes, and stages of decomposition, high basal area, large-diameter canopy dominants, multilayered canopies, numerous canopy gaps of diverse age and size, and pit and mound

microtopography from continual, frequent windthrow. Historically, where mesic southern forest bordered fire-dependent prairie, savanna, and oak woodland systems, it is likely that low-intensity surface fires occasionally burned portions of the ground layer and helped promote diversity by releasing nutrients and exposing a mineral soil seedbed.

Vegetation

Principal dominants of the canopy are American beech (*Fagus grandifolia*) and sugar maple (*Acer saccharum*), which together often make up over 80% of the canopy composition. Canopy associates include bitternut hickory (*Carya cordiformis*), white ash (*Fraxinus americana*), tulip tree (*Liriodendron tulipifera*), white oak (*Quercus alba*), red oak (*Q. rubra*), and basswood (*Tilia americana*). American elm (*Ulmus americana*) and ironwood (*Ostrya virginiana*) are common in the subcanopy. Sugar maple is the overwhelming dominant within the understory layer and often the ground layer. American beech, elm, and ironwood are also common saplings. Common shrub species include pawpaw (*Asimina triloba*), musclewood (*Carpinus caroliniana*), alternate-leaved dogwood (*Cornus alternifolia*), flowering dogwood (*Cornus florida*), leatherwood (*Dirca palustris*), witch-hazel (*Hamamelis virginiana*), spicebush (*Lindera benzoin*), American fly honeysuckle (*Lonicera canadensis*), prickly gooseberry (*Ribes cynosbati*), red elderberry (*Sambucus racemosa*), and maple-leaved arrow-wood (*Viburnum acerifolium*). Common vines include Virginia creeper (*Parthenocissus quinquefolia*), green briar (*Smilax* spp.), and poison ivy (*Toxicodendron radicans*). The ground flora is characterized by a prevalence of spring ephemerals, high diversity, and high degree of compositional similarity across its range. Common ground flora include spring beauty (*Claytonia virginica*), cut-leaved toothwort (*Dentaria laciniata*), squirrel corn (*Dicentra canadensis*), Dutchman's breeches (*D. cucullaria*), white trout lily (*Erythronium albidum*), yellow trout lily (*E. americanum*), false rue anemone (*Isopyrum biternatum*), doll's eyes (*Actaea pachypoda*), jack-in-the-pulpit (*Arisaema triphyllum*), wild ginger (*Asarum canadense*), blue cohosh (*Caulophyllum thalictroides*), wild geranium (*Geranium maculatum*), sharp-lobed hepatica (*Hepatica acutiloba*), Virginia waterleaf (*Hydrophyllum virginianum*), May apple (*Podophyllum peltatum*), bloodroot (*Sanguinaria canadensis*), common trillium (*Trillium grandiflorum*), large-flowered bellwort (*Uvularia grandiflora*), maidenhair fern (*Adiantum pedatum*), wild leek (*Allium tricoccum*), sedges (*Carex albursina* and *C. plantaginea*), enchanter's nightshade (*Circaea lutetiana*), beech drops (*Epifagus virginiana*), and running strawberry bush (*Euonymus obovata*).

Noteworthy Animals

Large contiguous tracts of old-growth and mature mesic southern forest provide important habitat for cavity nesters, species of detritus-based food webs, canopy-dwelling species, and interior forest obligates, including numerous neotropical migrants such as black-throated green warbler (*Dendroica virens*), scarlet tanager (*Piranga olivacea*), and ovenbird (*Seiurus aurocapillus*). Vernal pools within mesic southern forests provide critical habitat for reptiles and amphibians.

Rare Plants

Adlumia fungosa (climbing fumitory, state special concern)
Aristolochia serpentaria (Virginia snakeroot, state threatened)
Bromus nottowayanus (satin brome, state special concern)
Carex oligocarpa (eastern few-fruited sedge, state threatened)
Carex platyphylla (broad-leaved sedge, state endangered)
Castanea dentata (American chestnut, state endangered)
Dentaria maxima (large toothwort, state threatened)
Euphorbia commutata (tinted spurge, state threatened)
Galearis spectabilis (showy orchis, state threatened)
Gentianella quinquefolia (stiff gentian, state threatened)

Hybanthus concolor (green violet, state special concern)
Hydrastis canadensis (goldenseal, state threatened)
Jeffersonia diphylla (twinleaf, state special concern)
Liparis liliifolia (purple twayblade, state special concern)
Ophioglossum vulgatum (southeastern adder's tongue, state endangered)
Panax quinquefolius (ginseng, state threatened)
Phlox ovata (wideflower phlox, state endangered)
Polymnia uvedalia (large-flowered buttercup, state threatened)
Ruellia strepens (smooth ruellia, state endangered)
Scutellaria elliptica (hairy skullcap, state special concern)
Scutellaria ovata (heart-leaved skullcap, state threatened)
Smilax herbacea (smooth carrion-flower, state special concern)
Tipularia discolor (crane-fly orchid, state endangered)
Trillium recurvatum (prairie trillium, state threatened)
Trillium sessile (sessile trillium, state threatened)
Triphora trianthophora (three-birds orchid, state threatened)
Viburnum prunifolium (black haw, state special concern)
Vitis vulpina (frost grape, state threatened).

Rare Animals

Accipiter gentilis (northern goshawk, state special concern)
Ambystoma opacum (marbled salamander, state endangered)
Ambystoma texanum (smallmouth salamander, state endangered)
Buteo lineatus (red-shouldered hawk, state threatened)
Dendroica cerulea (cerulean warbler, state threatened)
Dryobius sexnotatus (six-banded longhorn beetle, state threatened)
Emydoidea blandingii (Blanding's turtle, state special concern)
Mesodon elevatus (proud globe, state threatened)
Microtus pinetorum (woodland vole, state special concern)
Nerodia erythrogaster neglecta (copperbelly watersnake, federal threatened and state endangered)
Nicrophorus americanus (American burying beetle, federal/state endangered)
Pantherophis spiloides (gray ratsnake, state special concern)
Protonotaria citrea (prothonotary warbler, state special concern)
Seiurus motacilla (Louisiana waterthrush, state threatened)
Terrapene c. carolina (eastern box turtle, state special concern)
Wilsonia citrina (hooded warbler, state special concern)

Biodiversity Management Considerations

When the primary conservation objective is to maintain or enhance biodiversity in mesic southern forests, the most appropriate management is to leave large tracts (especially old-growth and late-successional forest) unharvested and allow natural processes to operate unhindered. Conservation and restoration of fragmented mesic forest communities require active, long-term management of deer at low densities. Where resources are available, deer exclosures may be erected around concentrations of sensitive herbs and susceptible saplings. Intensive management may also be required to control non-native species invasion in fragments of mesic southern forest. Limiting anthropogenic disturbance in large tracts of old-growth and mature mesic southern forest is the best means of reducing the possibility of invasive species establishment and domination. Much of Michigan's mesic southern forest is immature and has not yet attained the structural and compositional features of old-growth mesic forest. Mimicking gap-dominated disturbances and promoting dead tree dynamics can hasten old-growth, uneven-aged conditions in immature and

mature stands. Forest continuity can be maximized by retaining large-diameter snags, coarse woody debris, and old, living trees.

Intensive and pervasive anthropogenic disturbance during the past 150 years has altered the extent, landscape pattern, natural processes, structure, and species composition of mesic southern forest. Mesic southern forest, especially old-growth and late-successional forest, has been drastically reduced in acreage. This formerly matrix community type is now fragmented, with most old-growth and late-successional stands persisting as remnant patches enmeshed in a matrix of agricultural lands. The structure and composition of the remnants have been altered by selective logging, grazing, removal of snags and logs for firewood, deer herbivory, non-native species invasion, and introduced diseases and insect outbreaks (e.g., Dutch elm disease, chestnut blight, beech bark disease, and emerald ash borer). Structural alterations include the reduction of large-diameter trees, snags, and coarse woody debris and invasion of non-native shrubs and ground flora. Many fragments are dominated solely by sugar maple, which was often left to provide maple syrup and is favored in gaps created by selective logging. In addition, American beech was often culled because of its poor timber value. Conversely, many stands that were high-graded of valuable timber (i.e., sugar maple and red oak) are now beech-dominated. Chronically high deer densities have limited tree recruitment and altered floral composition and structure. Herbs of this community are highly susceptible to herbivory by deer. Herbaceous plants constitute 87% of deer's summer diet and often suffer from reduced flowering rates, survivorship, plant size, and extirpation due to herbivory by this keystone herbivore. Indirect impacts of deer herbivory can include the reduction of pollinators and seed dispersers of sensitive herbs. Nest predation by edge species and nest parasitism (mainly by cowbirds) increase with forest fragmentation and account for population declines of forest birds, especially neotropical migrants.

Monitoring and control activities to detect and remove invasive species are critical to the long-term viability of mesic southern forest. Invasive plant species that threaten the diversity and community structure in mesic southern forest include garlic mustard (*Alliaria petiolata*), Dame's rocket (*Hesperis matronalis*), Oriental bittersweet (*Celastrus orbiculatus*), Eurasian honeysuckles (*Lonicera morrowii*, *L. japonica*, *L. maackii*, *L. sempervirens*, *L. tatarica*, *L. xbella*, and *L. xylosteum*), Japanese barberry (*Berberis thunbergii*), common buckthorn (*Rhamnus cathartica*), glossy buckthorn (*R. frangula*), multiflora rose (*Rosa multiflora*), autumn olive (*Elaeagnus umbellata*), common privet (*Ligustrum vulgare*), European highbush cranberry (*Viburnum opulus*), and Norway maple (*Acer platanoides*).

Variation

Three physiographic subtypes of mesic southern forest occur in Michigan: one on the level, eastern lakeplains, one on the western sand dunes, and one on the glacial outwash plains and moraines between these areas.

Similar Natural Communities

Mesic northern forest, dry-mesic southern forest, southern hardwood swamp, floodplain forest, and wet-mesic flatwoods.

Relevant Literature

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For a full list of references used to create this description, please refer to the natural community abstract for mesic southern forest.

Boreal Forest

Global/State Rank: GU/S3

Overview

Boreal forest is a conifer or conifer-hardwood forest type occurring on moist to dry sites characterized by species dominant in the Canadian boreal forest. It typically occupies upland sites along shores of the Great Lakes, on islands in the Great Lakes, and locally inland. The community occurs north of the climatic tension zone primarily on sand dunes, glacial lakeplains, and thin soil over bedrock or cobble. Soils of sand and sandy loam are typically moderately acid to neutral, but heavier soils and more acid conditions are common. Proximity to the Great Lakes results in high levels of windthrow and climatic conditions characterized by low summer temperatures and high levels of humidity, snowfall, and summer fog and mist. Additional important forms of natural disturbance include fire and insect epidemics.

Landscape Context

Boreal forest typically occupies upland sites, often containing local wet depressions, along shores of the Great Lakes, on islands in the Great Lakes (e.g., Isle Royale, Drummond Island, and Beaver Island), and locally inland (e.g., areas within the Negaunee-Michigamme Highlands of the western Upper Peninsula). Coastal boreal forests occur primarily on sand dunes, in glacial lakeplains, and on thin soil over bedrock and cobble of both alkaline and acidic rock types. Farther inland, moderately to poorly drained lakeplain and outwash deposits occasionally support these forests. Within lakeplain, boreal forest is often found in areas with poorly expressed dune and swale topography. Along shorelines, boreal forest often shares an abrupt boundary with coastal communities such as sand and gravel beach, limestone cobble shore, volcanic cobble shore, sandstone cobble shore, limestone bedrock lakeshore, volcanic bedrock lakeshore, sandstone bedrock lakeshore, granite bedrock lakeshore, Great Lakes marsh, open dunes, and Great Lakes barrens. Farther inland boreal forest gradually grades to mesic northern forest, dry-mesic northern forest, or less frequently, rich conifer swamp, granite bedrock glade, limestone bedrock glade, volcanic bedrock glade, or alvar. Coastal boreal forests on the mainland often form narrow, linear bands along the shoreline while archipelagic boreal forests more frequently occupy broader areas of variable shape along island shorelines, especially along the southwestern portions of islands. Nearshore boreal forests occupy peninsulas, former embayments, and coves. Topography of boreal forests ranges widely from gently sloping on lakeplain systems to steep topography on high dune fields, especially where aeolian features have been deposited on moraines.

Soils

Sand, loamy sand, and sandy loam soils are typically moderately acid to neutral, but heavier soils (e.g., silty loam and clay loams) and more acid and alkaline conditions are also found. Boreal forests that occur over bedrock or cobble are often characterized by shallow organic soils or mor humus. Where conifers dominate the canopy, the litter layer is typically more acidic than the underlying organic and mineral soils. Water-retaining capacity of the soils is variable with sandy soils typically being well-drained and soils with heavier texture, such as loams, ranging from moderately drained to poorly drained. Inland boreal forest systems usually occur on moderately to poorly drained lakeplain or outwash.

Natural Processes

Proximity to the Great Lakes results in the moderation of the microclimate of boreal forests with higher humidity, greater snowfall, lower summer temperatures, warmer winter temperatures, and greater summer fog and mist compared to the adjacent inland areas. Natural disturbance regimes are characterized by frequent windthrow, less frequent insect epidemics, and infrequent catastrophic fire. Because boreal forest frequently occurs near the Great Lakes shoreline and thin soils over rock prevent trees from rooting deeply, windthrow and snap-off rates are high; balsam fir is especially susceptible to windthrow and breakage. Spruce budworm (*Choristoneura fumiferana*) defoliates both spruce (*Picea glauca* and *P. mariana*) and balsam fir (*Abies balsamea*) but tends to be more detrimental to the latter. Interactions of blowdowns, insects, and climate (i.e., droughts) influence fire regimes of boreal forests. Infrequent catastrophic fires are an important disturbance factor, especially in inland boreal forests. Estimations for fire return interval for Canadian and Minnesotan boreal forests range from 50 to 150 years. Given the prevailing landscape position of most Great Lakes boreal forests (e.g., along the shoreline), the fire return interval for these systems was probably greater than 500 years, with fire cycles slightly shorter for inland sites. Large-scale disturbance events in boreal forests can lead to the development of even-aged stands, while small-scale disturbance factors can lead to uneven-aged systems.

Vegetation

The boreal forest flora is circumboreal in distribution with a high degree of floristic homogeneity from site to site. Most species within boreal forests bloom in early spring or summer. The canopy of boreal forests is characterized by a prevalence of conical-shaped evergreens, which often form a closed canopy. The dense tree coverage often results in a scattered understory and sparse ground cover due to the low levels of light transmitted through the canopy and dense sod formed by the extensive network of the shallowly rooted trees. The canopy is dominated by balsam fir (*Abies balsamea*), white spruce (*Picea glauca*), and northern white-cedar (*Thuja occidentalis*), often with lesser amounts of paper birch (*Betula papyrifera*) and quaking aspen (*Populus tremuloides*). Dominance shifts toward birch and aspen following fires, large blowdowns, and/or spruce budworm outbreaks, and back toward conifers in the absence of such disturbances. Northern white-cedar dominance is most prevalent in sand dunes and on thin soils over neutral to alkaline bedrock or glacial deposits, such as in the Straits of Mackinac. White spruce is more prevalent on drier sites while balsam fir and cedar are more common on wetter sites; all three of these conifer species increase in importance with time since fire, especially cedar. Additional canopy associates include white pine (*Pinus strobus*), balsam poplar (*Populus balsamifera*), and hemlock (*Tsuga canadensis*), and less frequently black spruce (*Picea mariana*), red pine (*Pinus resinosa*), jack pine (*Pinus banksiana*), and red maple (*Acer rubrum*). Inland boreal forests are often characterized by an increased canopy component of white pine, hemlock, and deciduous species. Mountain maple (*Acer spicatum*), striped maple (*A. pensylvanicum*), American mountain ash (*Sorbus americana*), and mountain ash (*S. decora*) are characteristic of the subcanopy and understory. Where aspen and/or birch dominate the canopy, conifers are prevalent in the subcanopy and understory. Additional understory or tall shrub species include round-leaved dogwood (*Cornus rugosa*), tag alder (*Alnus rugosa*), and soapberry (*Shepherdia canadensis*). Characteristic low shrubs include American fly honeysuckle (*Lonicera canadensis*), bearberry (*Arctostaphylos uva-ursi*), Canadian yew (*Taxus canadensis*), prickly gooseberry (*Ribes cynosbati*), Canada blueberry (*Vaccinium myrtilloides*), bush honeysuckle (*Diervilla lonicera*), common juniper (*Juniperus communis*), thimbleberry (*Rubus parviflorus*), and dwarf raspberry (*R. pubescens*). Ground flora includes species from both mesic northern forest and northern swamp communities such as red baneberry (*Actaea rubra*), wild sarsaparilla (*Aralia nudicaulis*), large-leaved aster (*Aster macrophyllus*), sedges (*Carex eburnea* and *C. deweyana*), bluebead lily (*Clintonia borealis*), goldthread (*Coptis trifolia*), bunchberry (*Cornus canadensis*), woodfern

(*Dryopteris* spp.), fragrant bedstraw (*Galium triflorum*), Menzies' rattlesnake plantain (*Goodyera oblongifolia*), creeping rattlesnake plantain (*G. repens*), wintergreen (*Gaultheria procumbens*), twinflower (*Linnaea borealis*), Canada mayflower (*Maianthemum canadense*), naked miterwort (*Mitella nuda*), partridge berry (*Mitchella repens*), northern wood sorrel (*Oxalis acetosella*), bracken fern (*Pteridium aquilinum*), gay wings (*Polygala paucifolia*), false mayflower (*Smilacina trifolia*), rose twisted stalk (*Streptopus roseus*), starflower (*Trientalis borealis*), and violet (*Viola* spp.). Ram's head lady's-slipper (*Cypripedium arietinum*, state special concern) and dwarf lake iris (*Iris lacustris*, federal/state threatened) are uncommon, but characteristic. Mosses and usnea lichens are often abundant due to favorable, moist conditions. Clubmosses, such as stiff clubmoss (*Lycopodium annotinum*), running ground pine (*L. clavatum*), and ground pine (*L. obscurum*), are often locally abundant, with ground pine more common following fire. Mosses, liverworts, usnea lichens, and saprophytic fungi often are common due to favorable, moist conditions.

Noteworthy Animals

Selective browsing by moose (*Alce alces*, state special concern) in the Upper Peninsula of Michigan can result in the alteration of species composition, community structure, and ultimately forest successional patterns of boreal forests. On sites with spruce and balsam fir, moose preferentially browse on balsam fir, retarding fir vertical growth, limiting fir abundance, and imparting a competitive advantage to spruce. As a predominantly coastal system, Michigan boreal forest and associated communities provide critical feeding, roosting, and perching habitat for migrating shorebirds, waterfowl, and songbirds in the spring. The majority of shrubs found within boreal forest have fleshy fruit, an important food source for birds such as grosbeak, crossbill, warblers, and white-throated sparrow (*Zonotrichia albicollis*). Paleontologists believe that mastodons (*Mammuth americanus*, extinct) were associated with spruce-dominated forests and that spruce was a dietary staple.

Rare Plants

Calypso bulbosa (calypso, state threatened)
Cypripedium arietinum (ram's head lady's-slipper, state special concern)
Disporum trachycarpum (northern fairy bells, state threatened)
Iris lacustris (dwarf lake iris, federal/state threatened)
Luzula parviflora (small-flowered wood rush, state threatened)
Phacelia franklinii (Franklin's phacelia, state threatened)
Piperia unalascensis (Alaska orchid, state special concern)
Pterospora andromedea (pine-drops, state threatened)
Viburnum edule (squashberry or mooseberry, state threatened)
Viola epipsila (northern palustrine violet or marsh violet, state endangered)

Rare Animals

Accipiter gentilis (northern goshawk, state special concern)
Alces americanus (moose, state special concern)
Canis lupus (gray wolf, federal endangered and state threatened)
Falci pennis canadensis (spruce grouse, state special concern)
Falco columbarius (merlin, state threatened)
Haliaeetus leucocephalus (bald eagle, state special concern)
Lynx canadensis (lynx, state endangered)
Pandion haliaetus (osprey, state special concern)
Picoides arcticus (black-backed woodpecker, state special concern)
Polygona gracilis (hoary comma, state special concern)
Proserpinus flavofasciata (yellow-banded day-sphinx, state special concern)
Pseudacris maculata (boreal chorus frog, state special concern)

Sistrurus c. catenatus (eastern massasauga, federal candidate species and state special concern)
Sorex fumeus (smoky shrew, state threatened)
Vallonia gracilicosta albula (land snail, state endangered)

Biodiversity Management Considerations

As a predominantly coastal system, boreal forest and associated communities provide critical feeding, roosting, and perching habitat for migrating shorebirds, waterfowl, and songbirds in the spring. Numerous rare and unique species are associated with boreal forest. When the primary conservation objective is to maintain biodiversity in boreal forests, the best management is to leave large tracts unharvested and allow natural processes (e.g., windthrow, insect defoliation, and fire) to operate unhindered and stochastically generate a range of successional stages. It is crucial to allow dead and dying wood to remain within these systems to become snags, stumps, and fallen logs. Within areas managed solely for biodiversity, resource practitioners should refrain from salvage harvesting following fire, wind, and insect disturbance. Salvage logging, especially following fire, can severely diminish nutrient pools and site productivity in addition to reducing structural heterogeneity.

Chronically high deer densities over the last half-century (or more) have altered tree recruitment, community structure, and floristic composition of Great Lakes forests. Woody plant species unpalatable to deer or tolerant of browsing (e.g., aspens, balsam fir, and red maple) have increased, while species intolerant of deer browsing have decreased (e.g., cedar, hemlock, white pine, yellow birch, and Canadian yew). Reducing deer browse pressure on cedar is a special concern in the Straits of Mackinac, where cedar serves as a canopy dominant.

Currently, logging, shoreline development, and excessive browsing by deer are the primary threats to boreal forests. Few invasive species are presently established in boreal forest but instead pose a potential future threat. Monitoring and control efforts to detect and remove invasive species before they become well established is critical to the long-term viability of the community. Particularly aggressive invasive species that may threaten boreal forest diversity and structure include garlic mustard (*Alliaria petiolata*), Dame's rocket (*Hesperis matronalis*), common buckthorn (*Rhamnus cathartica*), glossy buckthorn (*R. frangula*), multiflora rose (*Rosa multiflora*), autumn olive (*Elaeagnus umbellata*), Eurasian honeysuckles (*Lonicera morrowii*, *L. japonica*, *L. maackii*, *L. sempervirens*, *L. tatarica*, *L. xbella*, and *L. xylosteum*), multiflora rose (*Rosa multiflora*), and Norway maple (*Acer platanoides*).

Variation

Following disturbance, boreal forests are characterized by an increased canopy component of early-successional species such as aspen and paper birch. Inland boreal forests typically have more white pine, hemlock, and deciduous species in the canopy compared to coastal boreal forests. Dominance by northern white-cedar is most prevalent on sand dunes and thin soils over neutral to alkaline bedrock or glacial deposits. Coastal boreal forests occurring along the mainland often form narrow, linear bands while archipelagic boreal forests often occupy broader areas of variable shape along island shorelines.

Similar Natural Communities

Rich conifer swamp, mesic northern forest, hardwood-conifer swamp, dry-mesic northern forest, Great Lakes barrens, limestone bedrock glade, granite bedrock glade, volcanic bedrock glade, and wooded dune and swale complex.

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For a full list of references used to create this description, please refer to the natural community abstract for boreal forest.

PRIMARY COMMUNITIES

Sand and Gravel Beach

Global/State Rank: G3?/S3

Overview

Sand and gravel beaches occur along the shorelines of the Great Lakes and on some of Michigan's larger freshwater lakes, where wind, waves, and winter ice cause the shoreline to be too unstable to support aquatic vegetation. Because of the high levels of disturbance, these beaches are typically quite open, with sand and gravel sediments and little or no vegetation.

Landscape Context

Sand and gravel beaches occur along the shorelines of the Great Lakes and on some of Michigan's larger freshwater lakes, where the energy from waves and ice abrasion are adequate to maintain an open beach. Natural communities occurring adjacent to sand and gravel beach include open dunes, interdunal wetlands, wooded dune and swale complex, cobble shore, bedrock lakeshore, and lakeshore cliffs.

Soils

The dynamic nature of open sand and gravel beaches greatly inhibits soil development. Uprooted trees accumulate on some beaches, fostering localized sand accretion and often vegetation establishment. Finer organic material also builds up seasonally on beaches, and can include plant debris, algae, and dead lake or wetland organisms such as insects, fish, and zebra mussels (*Dreissena polymorpha*), a small invasive bivalve mussel. These aggregations can be large, greatly increasing the nutrient availability and changing the sediment characteristics of the beach, although these changes are often temporary due to the dynamics of the shoreline environment. Storm waves and winter ice typically prevent permanent vegetation establishment and soil development. Where organic sediments are protected from erosive forces, vegetation can establish, stabilize the shoreline, and thus eliminate portions of the open beach.

Natural Processes

The openness of beach vegetation is the result of the unstable sediment conditions caused by wind, waves, and winter ice. Beaches tend to accumulate sand during less windy spring and summer periods, and lose sand through erosion during strong fall and winter storms. Gravel movement along the shoreline is generated completely by wave or ice movement, while sand can also be moved by wind after its deposition on the beach, often leading to dune development farther inland. While many species of plants are able to establish on sand or gravel beaches, the extreme conditions of desiccation and erosion allow few species to reach maturity and set seed. Severity of desiccation increases as particle size increases, but on many gravel beaches vegetation can establish because finer particles of sand are trapped among the gravel. On sand beaches, successful vegetation establishment causes an increase in surface roughness, slowing both the wind and movement of sand, and resulting in the accumulation of sand in the form of coastal dunes. Vegetation cover increases with distance from the water's edge due to decreasing levels of erosive wind and water energy. Because water levels fluctuate on many lakes, vegetation cover can increase during periods of low water. Sand beaches regularly migrate with changing water levels and shoreline configuration.

Vegetation

Sand and gravel beach is characterized by both a low diversity of plant species and low levels of plant cover. A wide variety of plants can develop at the inland margin of sand and gravel beaches, but few establish and persist on the active beach, where there is often intense wind and wave action, resulting in almost constantly moving sand. Among the few species able to survive the dynamic beach zone are sea rocket (*Cakile edentula*), seaside spurge (*Euphorbia polygonifolia*), Baltic rush (*Juncus balticus*), silverweed (*Potentilla anserina*), beach pea (*Lathyrus japonicus*), and marram grass (*Ammophila breviligulata*). The rare Great Lakes endemic Pitcher's thistle (*Cirsium pitcheri*, federal/state threatened) occasionally establishes on active sand beaches during low-water periods. The community typically contains a zone of open sand along the water's edge, with only scattered stems of the above-mentioned species. Farther from the water, marram grass is able to stabilize the sand with its extensive roots and rhizomes, allowing for the accumulation of sand into a beach ridge above the zone of active waves. Many more plant species can survive in this zone of sand accumulation, including many herbs, shrubs, and tree seedlings and saplings.

Noteworthy Animals

Sand beaches are favorite feeding grounds for shorebirds. Insects, birds, and other fauna feed intensively on dead and decomposing organic materials that accumulate along the shoreline. Large numbers of aquatic insects, such as midges, live in the sediments and provide important food for migratory songbirds during spring migration. In addition, butterflies often gather on the beach for moisture and nutrients during migration. Gravel beaches, especially on islands, are used by nesting gulls, terns, cormorants, and other waterbirds.

Rare Plants

Adlumia fungosa (climbing fumitory, state special concern)
Beckmannia syzigachne (slough grass, state threatened)
Calamagrostis lacustris (northern reedgrass, state threatened)
Cirsium pitcheri (Pitcher's thistle, federal/state threatened)
Elymus mollis (American dune wild-rye, state special concern)
Iris lacustris (dwarf lake iris, federal/state threatened)
Listera auriculata (auricled twayblade, state threatened)
Polygonum viviparum (alpine bistort, state threatened)
Potentilla paradoxa (sand cinquefoil, state threatened)
Salix pellita (satiny willow, state special concern)
Senecio congestus (marsh-fleabane, presumed extirpated from Michigan)
Tanacetum huronense (Lake Huron tansy, state threatened)

Rare Animals

Charadrius melodus (piping plover, federal/state endangered)
Trimerotropis huroniana (Lake Huron locust, state threatened)

Biodiversity Management Considerations

Off-road vehicles can destabilize beach areas, especially those areas farther from the shore where vegetation is becoming stabilized. Eliminating illegal off-road vehicle activity is a primary means of protecting the ecological integrity of sand and gravel beaches. Raccoons and unleashed dogs are a major threat to piping plovers, and high levels of human visitation to plover beaches can also result in low breeding success. Many parks actively maintain open beach conditions by mechanical grooming, eliminating the natural flora and fauna of the beach.

Variation

There is considerable variability in sand and gravel, based on the rock from which the sands and gravels formed. In portions of the Keweenaw Peninsula, sand-sized mine wastes form broad beaches of dark sand, especially along the Portage Shipping Canal, but because of their anthropogenic origin, these areas are not considered a natural community.

Similar Natural Communities

Open dunes, limestone cobble shore, sandstone cobble shore, volcanic cobble shore, and wooded dune and swale complex.

Relevant Literature

- Albert, D.A. 2007. Natural community abstract for sand and gravel beach. Michigan Natural Features Inventory, Lansing, MI. 7 pp.
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- Ritter, D.F., R.C. Kochel, and J.R. Miller. 1995. Process geomorphology. Third Edition. William C. Brown, Dubuque, IA. 546 pp.

For a full list of references used to create this description, please refer to the natural community abstract for sand and gravel beach.

Open Dunes

Global/State Rank: G3/S3

Overview

Open dunes is a grass- and shrub-dominated multi-seral community located on wind-deposited sand formations near the shorelines of the Great Lakes. Dune formation and the patterning of vegetation are strongly affected by lake-driven winds. The greatest concentration of open dunes occurs along the eastern and northern shorelines of Lake Michigan, with the largest dunes along the eastern shoreline due to the prevailing southwest winds.

Landscape Context

Dune formation is a dynamic, cyclic process that appears to be linked to high water levels in the Great Lakes. An early period of dune formation coincided with Glacial Lake Algonquin (approximately 11,000 years ago). During the Nipissing period (4,000 to 6,000 years ago), when Great Lakes levels were considerably higher than today, the Grand Sable Dunes on Lake Superior and the Nordhouse Dunes along northern Lake Michigan formed. Other Lake Michigan dune complexes, including those near Muskegon and Grand Haven, were formed during high-water periods as recently as 3,000 years ago. Characteristic topographic features of most sand dunes include beaches, foredunes, high dunes, perched dunes, dune fields, interdunal swales, and blowouts. The slope on the windward face of dunes is gentle, usually not more than 15 degrees. On the lee or back side of the dune, the slope is much steeper and may reach the “angle of repose” of dry sand. Open dunes are typically nestled within a forested landscape, with the dune sands supporting a variety of forest types depending on slope, aspect, and geographic location; southern forest types are restricted to the southern Lower Peninsula but northern types such as mesic northern forest may occur on dune sands both north and south of the climatic tension zone.

Soils

Dune sand consists largely of quartz (87-94%), with lesser amounts of feldspar (10-18%), magnetite (1-3%), and traces of other minerals, such as calcite, garnet, and hornblende. Sand particles are rounded and frosted by continuous collisions with other sand grains. Because the sand contains calcareous minerals, it is neutral to slightly alkaline.

Natural Processes

A combination of water erosion and wind deposition resulted in the formation of Great Lakes coastal dunes. The sand source for the coastal dunes was glacial sediment that was eroded by streams and by waves eroding bluffs along the Great Lakes shoreline. These sediments were then moved along the Great Lakes shoreline by nearshore currents, and then deposited along the shoreline by wave action. Strong winds then carried the sands inland, creating dunes.

Dune vegetation is adapted to constant sand burial and abrasion. As plants are buried by sand, they continue to form new growth above the sand while their roots and rhizomes continue to grow and stabilize the sand. As vegetation of the dunes is stabilized, herb and shrub diversity increases, and there is a gradual accumulation of organic soils and eventual transition to forest. At the forest edge, colonizers include oak in the southern part of the state and pine in both the north and south. When lake levels recede, beach and dune areas increase, permitting lakeward expansion of savanna and forest, but when lake levels rise, blowouts expand into the forest. The open, dry conditions of the sand dunes provided ideal conditions for the establishment of fire-dependent

oaks and pines. Lightning fires ignited patches of dune grasses and leaf litter, allowing these fire-dependent savanna and forest communities to persist at the borders of the open dune.

Vegetation

Dominant species and community structure vary depending on degree of sand deposition, sand erosion, and distance from the lake. The beach is dominated by annuals, including sea rocket (*Cakile edentula*). Depositional areas, such as foredunes, are dominated by marram grass (*Ammophila breviligulata*). Erosional areas, such as slacks in blowouts and dune fields, are dominated by sand reed grass (*Calamovilfa longifolia*), while more stabilized areas are dominated by little bluestem (*Andropogon scoparius*). In dune fields and on the most stable dune ridges, low evergreen shrubs like bearberry (*Arctostaphylos uva-ursi*) and creeping juniper (*Juniperus horizontalis*) occupy dune crests. Less frequent dominants include sand cherry (*Prunus pumila*), willows (*Salix cordata*, *S. serissima*, and *S. myricoides*), and common juniper (*Juniperus communis*). Characteristic dune species include sea rocket, beach pea (*Lathyrus japonicus*), seaside spurge (*Euphorbia polygonifolia*), marram grass, sand reed grass, little bluestem, plains puccoon (*Lithospermum carolinense*), Pitcher's thistle (*Cirsium pitcheri*, federal/state threatened), Lake Huron tansy (*Tanacetum huronense*, state threatened), wormwood (*Artemisia campestris*), harebell (*Campanula rotundifolia*), milkweed (*Asclepias syriaca*), sand cherry, red-osier dogwood (*Cornus stolonifera*), willows, common juniper, quaking aspen (*Populus tremuloides*), and balsam poplar (*P. balsamifera*). Approximately 25-35% of open dunes species also grow on maritime dunes (e.g., sea rocket, marram grass, beach heath [*Hudsonia tomentosa*], and beach pea). The many western plant species set open dunes apart, as do its endemic plants.

All dunes have distinctive zones (beach, foredune, interdunal wetland or trough, and backdune) determined largely by the physical processes of dune formation: transport of sand along the shore by waves and current, followed by wind-transport of sand to create dunes. The beach is the most dynamic zone, where wind, waves, and coastal currents create an ever-changing environment. Scattered plants of sea rocket are often found growing near the water's edge. Farther up the beach, plants tolerant of strong winds and high temperatures, such as beach pea and seaside spurge, are able to establish. The foredune is the zone where pioneering grasses, especially marram grass, allow sand to accumulate, enabling additional plants to establish. Eventually the grasses, herbs, and shrubs stabilize the sand enough that larger backdunes form behind the foredune. Backdunes are often forested, but blowouts occasionally occur. Open sand within the blowout is soon colonized by dune grasses, which stabilize the sand and facilitate the formation of an open dune community.

Noteworthy Animals

Many animals of the dunes are adapted to the extreme surface temperatures of the dune, which regularly reach 120° F (50° C) and locally reach 180° F (80° C). To survive such extremes, dune inhabitants like Fowler's toad (*Bufo fowleri*), eastern hognose snake (*Heterodon platyrhinos*), spider wasps (Family *Pompilidae*), and wolf spiders (Family *Lycosidae*) burrow down to reach cooler temperatures and are active at the surface only from evening to morning, when the temperatures are lower. Antlions (Family *Myrmeleontidae*) have adapted to the environment by building funnel-shaped sand traps where insects and ants become trapped.

Rare Plants

Adlumia fungosa (climbing fumitory, state special concern)
Botrychium acuminatum (acute-leaved moonwort, state endangered)
Botrychium campestre (prairie moonwort, state threatened)
Botrychium hesperium (western moonwort, state threatened)
Botrychium mormo (goblin moonwort, state threatened)

Botrychium spathulatum (spatulate moonwort, state threatened)
Bromus pumpellianus (Pumpelly's brome grass, state threatened)
Calypso bulbosa (calypso, state threatened)
Carex platyphylla (broad-leaved sedge, state endangered)
Carex seorsa (sedge, state threatened)
Cirsium hillii (Hill's thistle, state special concern)
Cirsium pitcheri (Pitcher's thistle, federal/state threatened)
Crataegus douglasii (Douglas's hawthorn, state special concern)
Cypripedium arietinum (ram's head lady's-slipper, state special concern)
Danthonia intermedia (wild oatgrass, state special concern)
Elymus mollis (American dune wild-rye, state special concern)
Galearis spectabilis (showy orchis, state threatened)
Hieracium paniculatum (panicled hawkweed, state threatened)
Huperzia selago (fir clubmoss, state special concern)
Iris lacustris (dwarf lake iris, federal/state threatened)
Listera auriculata (auricled twayblade, state threatened)
Orobanche fasciculata (fascicled broom-rape, state threatened)
Panax quinquefolius (ginseng, state threatened)
Polygonum careyi (Carey's smartweed, state threatened)
Sabatia angularis (rose pink, state threatened)
Salix pellita (satiny willow, state special concern)
Solidago houghtonii (Houghton's goldenrod, federal/state threatened)
Stellaria longipes (stitchwort, state special concern)
Tanacetum huronense (Lake Huron tansy, state threatened)
Triplasis purpurea (sand grass, state special concern)
Trisetum spicatum (downy oat-grass, state special concern)
Vitis vulpina (frost grape, state threatened)

Rare Animals

Charadrius melodus (piping plover, federal/state endangered)
Dendroica discolor (prairie warbler, state endangered)
Euxoa aurulenta (dune cutworm, state special concern)
Sterna caspia (Caspian tern, state threatened)
Sterna hirundo (common tern, state threatened)
Trimerotropis huroniana (Lake Huron locust, state threatened)

Biodiversity Management Considerations

Major threats to open dunes include off-road vehicles, recreational overuse, residential development, sand mining, and invasive plants and animals. While blowouts are a natural occurrence, their frequency is greatly exacerbated by human activities that erode vegetation cover. Off-road vehicles and recreational overuse can destroy plants that stabilize dunes, leading to large blowouts during heavy storms and significantly reducing vegetation cover from both massive wind erosion and burial of existing flora and fauna. Eliminating illegal off-road vehicle activity is a primary means of protecting the ecological integrity of open dunes and associated shoreline communities. Residential development destroys dune habitat, results in introductions of invasive plants, and prevents natural dune movement, which many dune plants require. In addition, roaming pets disrupt ground-nesting birds, some of which are globally rare. Sand mining directly destroys dunes. Invasive plants can eliminate native dune plants through competition for resources and by stabilizing dunes, which results in the loss of plants that rely on shifting sand and facilitates conversion to closed-canopy forest. Invasive plants that threaten the diversity and community structure in open dunes include spotted knapweed (*Centaurea*

maculosa), baby's breath (*Gypsophila paniculata*), common St. John's-wort (*Hypericum perforatum*), ox-eye daisy (*Chrysanthemum leucanthemum*), bull thistle (*Cirsium vulgare*), lyme grass (*Leymus arenarius*), white sweet-clover (*Melilotus alba*), common mullein (*Verbascum thapsus*), black swallow-wort (*Vincetoxicum nigrum*), white swallow-wort (*Vincetoxicum rossicum*), hoary alyssum (*Berteroa incana*), Kentucky bluegrass (*Poa pratensis*), Canada bluegrass (*P. compressa*), quack grass (*Agropyron repens*), timothy (*Phleum pratense*), hawkweeds (*Hieracium* spp.), sheep sorrel (*Rumex acetosella*), black locust (*Robinia pseudoacacia*), white poplar (*Populus alba*), Lombardy poplar (*P. nigra* var. *italica*), common buckthorn (*Rhamnus cathartica*), glossy buckthorn (*R. frangula*), autumn olive (*Elaeagnus umbellata*), Eurasian honeysuckles (*Lonicera morrowii*, *L. japonica*, *L. maackii*, *L. sempervirens*, *L. tatarica*, *L. xbella*, and *L. xylosteum*), and multiflora rose (*Rosa multiflora*). Monitoring and control efforts to detect and remove invasive species are critical to the long-term viability of open dunes.

Variation

Four distinctive types of dunes occur in Michigan: parabolic, perched, linear, and transverse. Parabolic and perched dunes support open, herb- and shrub-dominated plant communities, while linear and transverse dunes are often forested. Parabolic dunes, large complexes of U-shaped dunes up to 300 ft high along eastern Lake Michigan, formed 11,000 to 13,000 years ago during high lake levels. Perched dunes rest on morainal bluffs along eastern Lake Michigan and southeastern Lake Superior. While the morainal bluffs can be 27 to 110 m (90 to 360 ft) high, the perched dunes are much smaller. Linear dunes, or dune and swale complexes, are arcuate (i.e., curving) complexes of roughly parallel dune ridges separated by narrow swales that formed as Great Lakes water levels receded. Typical linear dunes are only about 3 to 5 m (10 to 15 ft) high and 9 to 30 m (30 to 100 ft) wide. Transverse dunes, linear to scalloped in shape, formed in shallow bays along the edge of the glaciers 11,000 years ago. Strong winds blew off the glaciers, forming a series of long, linear dunes, oriented perpendicularly to the wind. They are generally 9 to 18 m (30 to 60 ft) high with a steep south face and are surrounded by shallow peatlands. Various types of open dune are found in all of the Great Lakes states and provinces, including Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, Wisconsin, and the Canadian province of Ontario. Vermont also has sand dunes along Lake Champlain.

Similar Natural Communities

Great Lakes barrens, pine barrens, oak-pine barrens, interdunal wetland, sand and gravel beach, wooded dune and swale complex, and dry sand prairie.

Relevant Literature

- Albert, D.A. 1999. Natural community abstract for open dunes. Michigan Natural Features Inventory, Lansing, MI. 5 pp.
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- Olson, J. 1958. Rates of succession and soil changes on southern Lake Michigan sand dunes. *Botanical Gazette* 119: 125-170.
- Thompson, T.A. 1992. Beach-ridge development and lake-level variation in southern Lake Michigan. *Sedimentary Geology* 80: 305-318.

For a full list of references used to create this description, please refer to the natural community abstract for open dunes.

Great Lakes Barrens

Global/State Rank: G3/S2

Overview

Great Lakes barrens is a coniferous savanna community of scattered and clumped trees, and an often dense, low or creeping shrub layer. The community occurs along the shores of the Great Lakes where it is often associated with interdunal wetland and open dune.

Landscape Context

Great Lakes barrens occur on sandy former lake embayments along Great Lakes shorelines. They may occur in dune fields and in depressions between dune ridges within open dunes and may grade to interdunal wetlands where depressions are in contact with underlying groundwater. The surrounding landscape is typically forested, with the dune sands supporting a variety of forest types depending on slope, aspect, and geographic location.

Soils

The sand soils are circumneutral and dry. Subsoil water levels in depressions are periodically elevated by changes in Great Lakes water levels.

Natural Processes

This woodland community develops on dune fields and in protected depressions between dunes, where sand is stable enough to allow trees to establish and mature. However, periodic episodes of sand movement and vegetation burial do occur between dune ridges. The prevalence of jack pine is probably the result of extreme growing-season frosts within the low depressions, which kill most other woody species. Tree mortality also occasionally occurs when Great Lakes water levels rise, causing an increase in water levels within the low interdunal depressions and flooding of trees. Prolonged periods of flooding can result in the establishment of wetland vegetation and formation of interdunal wetlands. Open, dry conditions allow jack pine to establish rapidly when water levels drop.

Vegetation

The most dominant tree species of the open canopy is jack pine (*Pinus banksiana*), followed by white pine (*P. strobus*). Other trees of the scattered canopy of Great Lakes barrens include red pine (*P. resinosa*), white spruce (*Picea glauca*), cottonwood (*Populus deltoides*), balsam poplar (*P. balsamifera*), and paper birch (*Betula papyrifera*). The low shrub layer is well represented because of the open canopy, with dense common juniper (*Juniperus communis*) and bearberry (*Arctostaphylos uva-ursi*) most common, followed by creeping juniper (*J. horizontalis*), beach heath (*Hudsonia tomentosa*), poison ivy (*Toxicodendron radicans*), sand cherry (*Prunus pumila*), and soapberry (*Shepherdia canadensis*). Dune grasses are prevalent in the ground layer, especially marram grass (*Ammophila breviligulata*), sand reed grass (*Calamovilfa longifolia*), and little bluestem (*Andropogon scoparius*). Other characteristic grasses include poverty grass (*Danthonia spicata*), fescue (*Festuca saximontana*), June grass (*Koeleria macrantha*), hair grass (*Deschampsia flexuosa*), wheat grass (*Agropyron dasystachyum*), and slender wheat grass (*A. trachycaulum*). Wormwood (*Artemisia campestris*), starry false Solomon's seal (*Smilacina stellata*), and plains puccoon (*Lithospermum caroliniense*) are the most common forbs. Other species of stable sandy habitats and open dunes are typically present, including rough sand sedge (*Cyperus schweinitzii*), cudweeds (*Gnaphalium* spp.), and cow-wheat (*Melampyrum lineare*).

Moss and lichen cover is typically partial. Commonly occurring species include *Tortula tortuosa*, *Leucobryum glaucum*, *Cladina rangiferina*, and British soldiers (*Cladonia cristatella*).

Noteworthy Animals

Conditions in barrens are similar to those of open dunes, where animals are adapted to extreme surface temperatures, which regularly reach 120° F (50° C) or more. To survive, dune inhabitants like Fowler's toad (*Bufo fowleri*), eastern hognose snake (*Heterodon platyrhinos*), spider wasps (Family *Pompilidae*), and wolf spiders (Family *Lycosidae*) burrow down to reach cooler temperatures and are active at the surface only from evening to morning, when the temperatures are lower. Antlions (Family *Myrmeleontidae*) have adapted to the environment by building funnel-shaped sand traps where insects and ants become trapped.

Rare Plants

Botrychium acuminatum (acute-leaved moonwort, state endangered)

Botrychium campestre (prairie moonwort, state threatened)

Botrychium hesperium (western moonwort, state threatened)

Cirsium pitcheri (Pitcher's thistle, federal/state threatened)

Orobanche fasciculata (clustered broom-rape, state threatened)

Pterospora andromedea (pine-drops, state threatened)

Rare Animals

Dendroica discolor (prairie warbler, state endangered)

Falco columbarius (merlin, state threatened)

Trimerotropis huroniana (Lake Huron locust, state threatened)

Biodiversity Management Considerations

Off-road vehicles result in sand destabilization, which can bury the trees and other vegetation of Great Lakes barrens and the herbaceous or shrub vegetation of adjacent interdunal wetlands. Eliminating illegal off-road vehicle activity is a primary means of protecting the ecological integrity of Great Lakes barrens and associated shoreline communities. Invasive plants such as spotted knapweed (*Centaurea maculosa*), baby's breath (*Gypsophila paniculata*), common St. John's-wort (*Hypericum perforatum*), and common mullein (*Verbascum thapsus*) can stabilize vegetation and result in the loss of dune plants that rely on shifting sand, thereby facilitating the conversion to closed-canopy forest. Monitoring and control efforts to detect and remove invasive species are critical to the long-term viability of Great Lakes barrens.

Variation

Where the community occurs as part of a complex of open dunes, Great Lakes barrens typically dominate the drier depressions between dune ridges, while interdunal wetlands occupy the wet depressions.

Similar Natural Communities

Open dunes, interdunal wetland, pine barrens, and oak-pine barrens.

Relevant Literature

Albert, D.A. 2000. Borne of the wind: An introduction to the ecology of Michigan sand dunes. Michigan Natural Features Inventory, Lansing, MI. 63 pp.

Arbogast, A.F., and W.L. Loope. 1999. Maximum-limiting ages of Lake Michigan coastal dunes: Their correlation with Holocene lake level history. *Journal of Great Lakes Research* 25: 372-383.

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- Lichter, J. 1998. Primary succession and forest development on coastal Lake Michigan sand dunes. *Ecological Monographs* 68: 487-510.
- Olson, J. 1958. Rates of succession and soil changes on southern Lake Michigan sand dunes. *Botanical Gazette* 119: 125-170.
- Thompson, T.A. 1992. Beach-ridge development and lake-level variation in southern Lake Michigan. *Sedimentary Geology* 80: 305-318.

Alvar

Global/State Rank: G2/S1

Overview

Alvar is a grass- and sedge-dominated community, with scattered shrubs and sometimes trees. The community occurs on broad, flat expanses of calcareous bedrock (limestone or dolostone) covered by a thin veneer of mineral soil, often less than 25 cm deep. Alvars are only known from three areas of the world: the Basaltic region of northern Europe, Counties Clare and Galway of northwest Ireland, and the Great Lakes region south of the Canadian Shield. In Michigan, most of the sites occur in the Upper Peninsula along the shorelines of Lake Huron and Lake Michigan, in a band from Drummond Island to Cedarville, west to Seul Choix Point on the Garden Peninsula. Alvar also occurs farther west and inland along the Escanaba River. In the Lower Peninsula, alvar occurs on Thunder Bay Island and along the Lake Huron shoreline near Rogers City, Alpena, and Thompson's Harbor. The plant community is also referred to as alvar grassland.

Landscape Context

In Michigan, alvar is commonly found near northern Great Lakes shores where flat bedrock pavement is exposed. Bedrock types include both limestone and dolostone of Middle and Late Ordovician and Early Silurian origin (405 to 500 million years ago), when shallow, inland seas covered the Lake Michigan and Lake Huron basins. Much of this limestone has been converted through geological processes to dolomite or dolostone, a magnesium-rich form of limestone. Bedrock of Thunder Bay Island dates to the more recent Devonian period (345 to 405 million years ago). Topography of alvar is flat, and horizontal plates of bedrock are sometimes exposed, giving the impression of, and earning the name, "pavement" or "limestone pavement."

The surrounding uplands typically support areas of limestone glade (alvar glade), boreal forest, and mesic northern forest. Typical lowlands associated with alvar include northern fen and rich conifer swamp.

Soils

Alvar soils are characterized by shallow soil over bedrock, with soil depth usually less than 25 cm (10 in). Soil texture is primarily loamy sand or sandy loam. Soil is saturated, or locally inundated in the spring, but becomes droughty later in summer. Thin layers of organic soil may develop in shallow depressions that remain wet for longer periods. Soil is mildly to moderately alkaline.

Natural Processes

Alvars are typically subjected to seasonal environmental extremes of soil saturation or inundation in the spring followed by drought in summer. Flooding is less prevalent where there are abundant enlarged cracks (grykes) in the rock, which provide improved internal drainage. The combination of shallow soil and extreme fluctuations in soil-water availability play an important role in controlling the establishment of trees. Historically, fire probably also played an important role in limiting tree establishment and maintaining open grasslands. Where trees do establish, they are typically stunted and windthrow is common due to shallow rooting in the thin soil.

Vegetation

Alvar is dominated primarily by grasses and sedges, with mosses and lichens dominant in the driest areas and on exposed bedrock. Scattered shrubs and occasionally trees may occur in areas

where soil depth is greatest or where cracks or grykes provide additional moisture needed by woody vegetation. Dominant grasses and sedges include little bluestem (*Andropogon scoparius*), prairie dropseed (*Sporobolus heterolepis*, state special concern), and bulrush sedge (*Carex scirpoidea*, state threatened). Where soil-water availability is flattened spike-rush (*Eleocharis compressa*, state threatened), big bluestem (*Andropogon gerardii*), mat muhly (*Muhlenbergia richardsonis*, state threatened), and cordgrass (*Spartina pectinata*) are often dominant. Additional commonly occurring grasses include ticklegrass (*Agrostis hyemalis*), Kalm's brome (*Bromus kalmii*), poverty grass (*Danthonia spicata*), and hair grass (*Deschampsia cespitosa*). Sedges common in alvar include Crawe's sedge (*Carex crawei*), Richardson's sedge (*C. richardsonii*, state special concern), bulrush sedge, and golden-seeded spike-rush (*Eleocharis elliptica*). Common forbs include small-leaved pussytoes (*Antennaria neglecta*), wild columbine (*Aquilegia canadensis*), hairy rock cress (*Arabis hirsuta*), rock sandwort (*Arenaria stricta*), harebell (*Campanula rotundifolia*), Indian paintbrush (*Castilleja coccinea*), field chickweed (*Cerastium arvense*), bastard toadflax (*Comandra umbellata*), common peppergrass (*Lepidium virginicum*), wild bergamot (*Monarda fistulosa*), prairie cinquefoil (*Potentilla arguta*), early buttercup (*Ranunculus fascicularis*), low calamint (*Calamintha arkansana*), balsam ragwort (*Senecio pauperculus*), and old-field goldenrod (*Solidago nemoralis*). Common shrubs include common juniper (*Juniperus communis*), shrubby cinquefoil (*Potentilla fruticosa*), fragrant sumac (*Rhus aromatica*), choke cherry (*Prunus virginiana*), and snowberry (*Symphoricarpos albus*). Trees commonly occurring in alvar include northern white-cedar (*Thuja occidentalis*), white spruce (*Picea glauca*), white pine (*Pinus strobus*), and quaking aspen (*Populus tremuloides*).

Noteworthy Animals

Beaver can (*Castor canadensis*) cause flooding in long, narrow depressions in the bedrock plain, providing conditions for the establishment of black ash (*Fraxinus nigra*) swamps. Many species of ants are found living in diverse niches in the bedrock landscape. American black bears (*Ursus americanus*) feed on the ants and other insects that inhabit alvar.

Rare Plants

Allium schoenoprasum var. *sibiricum* (wild chives, state threatened)
Asplenium trichomanes-ramosum (green spleenwort, state special concern)
Astragalus canadensis (Canadian milk vetch, state threatened)
Astragalus neglectus (Cooper's milk vetch, state special concern)
Calypso bulbosa (calypso, state threatened)
Carex richardsonii (Richardson's sedge, state special concern)
Carex scirpoidea (bulrush sedge, state threatened)
Cerastium brachypodum (shortstalk chickweed, state threatened)
Cirsium hillii (Hill's thistle, state special concern)
Cypripedium arietinum (ram's-head lady's-slipper, state special concern)
Cystopteris tennesseensis (Tennessee bladder fern, state threatened)
Danthonia intermedia (wild oatgrass, state special concern)
Eleocharis compressa (flattened spike-rush, state threatened)
Geum triflorum (prairie smoke, state threatened)
Gymnocarpium robertianum (limestone oak fern, state threatened)
Hedysarum alpinum (Alpine sainfoin, state endangered)
Hymenoxys herbacea (lakeside daisy, state endangered)
Iris lacustris (dwarf lake iris, federal/state threatened)
Muhlenbergia richardsonis (mat muhly, state threatened)
Panicum philadelphicum (Philadelphia panic-grass, state threatened)
Pellaea atropurpurea (purple cliff-brake, state threatened)
Pinguicula vulgaris (butterwort, state special concern)

Piperia unalascensis (Alaska orchid, state special concern)
Poa alpina (alpine bluegrass, state threatened)
Scutellaria parvula (small skullcap, state threatened)
Solidago houghtonii (Houghton's goldenrod, federal/state threatened)
Sporobolus heterolepis (prairie dropseed, state special concern)
Trichostema brachiatum (false pennyroyal, state threatened)
Trisetum spicatum (downy oat-grass, state special concern)
Viola novae-angliae (New England violet, state threatened)
Viola pedatifida (prairie birdfoot violet, state threatened)

Rare Animals

Catinella exile (Pleistocene catinella, state threatened)
Flexamia delongi (leafhopper, state special concern)
Lanius ludovicianus migrans (loggerhead shrike, state endangered)
Prosapia ignipectus (red-legged spittlebug, state special concern)
Pyrgus wyandot (grizzled skipper, state special concern)
Sistrurus c. catenatus (eastern massasauga, federal candidate species and state special concern)
Vertigo elatior (tapered vertigo, state special concern)
Vertigo hubrichti (Hubricht's vertigo, endangered)
Vertigo morsei (six-whorl vertigo, endangered)

Biodiversity Management Considerations

Major threats are related to road construction, quarry development, off-road vehicle use, invasive species, and trampling of vegetation. Road construction results in modification of the hydrology by disrupting overland surface flows, typically flooding one side of the road and drying out the other. Road corridors and associated maintenance facilitate the rapid introduction and expansion of invasive plants. Invasive plants that may threaten diversity and community structure of alvar include Canada bluegrass (*Poa compressa*), Kentucky bluegrass (*Poa pratensis*), common St. John's-wort (*Hypericum perforatum*), spotted knapweed (*Centaurea maculosa*), rough-fruited cinquefoil (*Potentilla recta*), common mullein (*Verbascum thapsus*), timothy (*Phleum pratense*), ox-eye daisy (*Chrysanthemum leucanthemum*), curly dock (*Rumex crispus*), hawkweeds (*Hieracium* spp.), wild carrot (*Daucus carota*), blueweed (*Echium vulgare*), white sweet-clover (*Melilotus alba*), and common buckthorn (*Rhamnus cathartica*). Monitoring and control efforts to detect and remove invasive species are critical to the long-term viability of alvar. Eliminating illegal off-road vehicle activity is a primary means of protecting the ecological integrity of alvar.

The historical prevalence of fire in Michigan alvar is not well understood, but these level grasslands likely experienced occasional fires due to lightning strikes and anthropogenic causes. Prescribed fire management to maintain open conditions and species diversity should be implemented and if possible, followed by monitoring to assess changes in species composition and structure.

Variation

Limestones and dolomites vary in chemical composition, resistance to erosion, and depth and amount of crevice formation, all factors that affect soil development and plant species composition.

Similar Natural Communities

Limestone bedrock lakeshore, limestone bedrock glade, and boreal forest. Although alvar grassland may resemble prairies of southern Michigan in community structure, the climate, hydrology, soil properties, and species composition are much different.

Relevant Literature

- Albert, D.A. 2006. Natural community abstract for alvar. Michigan Natural Features Inventory, Lansing, MI. 8 pp.
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- Reed, R.C., and J. Daniels. 1987. Bedrock geology of northern Michigan. State of Michigan Department of Natural Resources. Map: 1: 500,000.
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- Schaefer, C.A., and D.W. Larson. 1997. Vegetation, environmental characteristics, and ideas on the maintenance of alvars on the Bruce Peninsula, Canada. *Journal of Vegetation Science* 8: 797-810.
- Stephenson, S.N., and P.S. Herendeen. 1986. Short-term drought effects on the alvar communities of Drummond Island, Michigan. *Michigan Botanist* 25: 16-27.

For a full list of references used to create this description, please refer to the natural community abstract for alvar.

BEDROCK GLADE COMMUNITIES

Limestone Bedrock Glade

Global/State Rank: G2G4/S2

Overview

Limestone bedrock glade consists of an herb- and graminoid-dominated plant community with scattered clumps of stunted trees and shrubs growing on thin soil over limestone or dolomite. Tree cover is typically 10 to 25%, but occasionally as high as 60%. Shrub and herb cover is variable and there are typically areas of exposed bedrock. Mosses, lichens, and algae can be abundant on the exposed limestone bedrock or thin organic soils. Seasonal flooding and summer drought maintain the open conditions. In Michigan, limestone bedrock glade occurs in the Upper Peninsula near the shorelines of Lakes Huron and Michigan, concentrated in a band from Drummond Island to Cedarville and from Gould City to the Garden Peninsula. In the Northern Lower Peninsula, limestone bedrock glade occurs along the Lake Huron shoreline near Rogers City, Alpena, and Thompson's Harbor. This community is also referred to as alvar glade.

Landscape Context

Limestone bedrock glade is most abundant along the Niagaran Escarpment, which is exposed on or near the north shores of Lakes Michigan and Huron, extending as far west as Wisconsin and as far east as the eastern Lake Ontario shoreline of New York. Limestone bedrock is also exposed in Presque Isle and Alpena Counties of Lower Michigan. Much of the limestone along the Niagaran Escarpment has been converted through geological processes to dolomite, a magnesium-rich form of limestone. Most of the limestone bedrock is relatively flat, with a very gradual slope to the south, but there are a few areas of limestone cliff as well. Limestone bedrock glade often occurs adjacent to limestone cobble shore, limestone bedrock lakeshore, alvar (alvar grassland), and boreal forest.

Soils

While large areas of limestone are bare of soil, where soils have developed, they are typically organic soils less than 30 cm (12 in) in depth. Soils are circumneutral and are generally saturated or flooded in the fall and spring, but are often droughty during summer months. Where there is no surface soil development, organic soils may accumulate in broad cracks (grykes) in the limestone pavement, where shrubs and trees often establish.

Natural Processes

The combination of flooded conditions in the spring and fall, with droughty conditions during the summer, maintains open conditions where trees are scattered and stunted. Seasonal flooding is less prevalent where there are abundant cracks in the rock, which provide improved internal drainage. However, sites with internal drainage are more prone to early desiccation and drought. Lightning fires may occasionally burn these sites, and there is speculation that Native Americans were responsible for some fires into the mid- to late nineteenth century. Strong winds off the Great Lakes result in windthrow of mature trees, which are shallowly rooted in the thin soils. Browsing by ungulates influences woody species composition and structure.

Vegetation

Limestone bedrock glade consists of an herb- and graminoid-dominated plant community with scattered clumps of stunted trees and shrubs. Tree cover typically ranges between 10 and 25%, with maximum tree cover of 60%. Dominant trees of the scattered and stunted canopy include northern white-cedar (*Thuja occidentalis*), white spruce (*Picea glauca*), paper birch (*Betula papyrifera*), and balsam fir (*Abies balsamea*). Additional characteristic trees include quaking aspen (*Populus tremuloides*) and balsam poplar (*P. balsamifera*). Common shrubs include soapberry (*Shepherdia canadensis*), bearberry (*Arctostaphylos uva-ursi*), choke cherry (*Prunus virginiana*), snowberry (*Symphoricarpos albus*), red-osier dogwood (*Cornus stolonifera*), common juniper (*Juniperus communis*), alder-leaved buckthorn (*Rhamnus alnifolia*), and bush honeysuckle (*Diervilla lonicera*). Common herbs include Canada mayflower (*Maianthemum canadense*), wild strawberry (*Fragaria virginiana*), large-leaved aster (*Aster macrophyllus*), small yellow lady's-slipper (*Cypripedium calceolus* var. *parviflorum*), yarrow (*Achillea millefolium*), wild columbine (*Aquilegia canadensis*), dwarf lake iris (*Iris lacustris*, federal/state threatened), wood lily (*Lilium philadelphicum*), balsam ragwort (*Senecio pauperculus*), northern bog violet (*Viola nephrophylla*), smooth aster (*Aster laevis*), harebell (*Campanula rotundifolia*), Indian paintbrush (*Castilleja coccinea*), and cow-wheat (*Melampyrum lineare*). Characteristic grasses and sedges include poverty grass (*Danthonia spicata*), slender wheat grass (*Agropyron trachycaulum*), rough-leaved rice grass (*Oryzopsis asperifolia*), ebony sedge (*Carex eburnea*), and Richardson's sedge (*Carex richardsonii*, state special concern). Bracken fern (*Pteridium aquilinum*) can also be common.

Vegetation zonation is minimal in limestone bedrock glade but some patterns may be evident. Large crevices provide additional moisture, nutrients, and footholds that allow shrubs and trees as well as herbaceous species to establish. Open portions of the glade, characterized by shallow soils, tend to support greater concentrations of herbs, lichens, and mosses. Nostoc and other algae are often concentrated in small, seasonally wet depressions.

Noteworthy Animals

Several ant species occupy various habitats within the glade, nesting beneath rocks, in dead wood, and in live wood of the drought-stressed trees. The abundance of ants and other insects attracts American black bears (*Ursus americanus*), which are common in some areas of limestone bedrock. The lime-rich habitat is home to many species of land snail as well, and the open grassland vegetation provides habitat for many prairie insects.

Rare Plants

Astragalus neglectus (Cooper's milk vetch, state special concern)
Calypso bulbosa (calypso, state threatened)
Carex richardsonii (Richardson's sedge, state special concern)
Carex scirpoidea (bulrush sedge, state threatened)
Cerastium brachypodum (shortstalk chickweed, state threatened)
Cirsium hillii (Hill's thistle, state special concern)
Cypripedium arietinum (ram's-head lady's-slipper, state special concern)
Cystopteris tennesseensis (Tennessee bladder fern, state threatened)
Iris lacustris (dwarf lake iris, federal/state threatened)
Panicum philadelphicum (Philadelphia panic-grass, state threatened)
Piperia unalascensis (Alaska orchid, state special concern)
Scutellaria parvula (small skullcap, state threatened)

Rare Animals

Flexamia delongi (leafhopper, state special concern)
Guppya sterki (Sterki's granule, state endangered)
Prosapia ignipectus (red-legged spittlebug, state special concern)
Pyrgus wyandot (grizzled skipper, state special concern)
Vertigo bollesiana (delicate vertigo, state threatened)
Vertigo elatior (tapered vertigo, state special concern)
Vertigo hubrichti (Hubricht's vertigo, endangered)
Vertigo nylanderi (deep-throat vertigo, endangered)
Vertigo paradoxa (land snail, state special concern)
Vertigo pygmaea (crested vertigo, state special concern)

Biodiversity Management Considerations

Principal threats to limestone glade are overgrazing, alteration of hydrology from road construction and off-road vehicle use, development, dumping of waste materials, and quarry development. All of these disturbances provide pathways for the introduction or spread of invasive plant species. Off-road vehicle use has degraded several glades on Drummond Island and the Garden Peninsula. High deer densities, especially on the Garden Peninsula, are influencing community structure and are likely negatively impacting species diversity and northern white-cedar's regeneration capacity.

Invasive species that threaten to reduce the diversity and alter the community structure of limestone bedrock glade include glossy buckthorn (*Rhamnus frangula*), common buckthorn (*R. cathartica*), spotted knapweed (*Centaurea maculosa*), ox-eye daisy (*Chrysanthemum leucanthemum*), Kentucky bluegrass (*Poa pratensis*), and Canada bluegrass (*P. compressa*). Monitoring and control efforts to detect and remove these and other invasive species before they become widespread will help maintain the native biodiversity of limestone bedrock glade and surrounding natural communities.

Given that the thin soils and slow-growing lichen and moss cover are sensitive to anthropogenic disturbance and recover slowly, conservation efforts should focus on preserving the ecological integrity of existing high-quality limestone bedrock glades. Prescribed burns may provide a useful management tool to maintain open conditions and increase herbaceous plant diversity, yet the response of this plant community to fire has not been well documented.

Variation

Local variability is common in this community, due to differences in slope, amount and depth of crevices, and even composition of the bedrock. While all of the bedrock where the glades occur is classified as limestone or dolomite, locally the rock contains large amounts of silt, sand, or clay, resulting in a lack of solution cracks. Still other areas on Huron Bay, Drummond Island, consist of thinly bedded shaly limestone. All of this variability affects species composition, leading to differences in both dominance and vegetation density among occurrences.

Similar Natural Communities

Alvar, limestone bedrock lakeshore, limestone cobble shore, limestone lakeshore cliff, limestone cliff, and boreal forest.

Relevant Literature

- Albert, D.A. 2007. Natural community abstract for limestone bedrock glade. Michigan Natural Features Inventory, Lansing, MI. 7 pp.
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- Schaefer, C.A., and D.W. Larson. 1997. Vegetation, environmental characteristics, and ideas on the maintenance of alvars on the Bruce Peninsula, Canada. *Journal of Vegetation Science* 8: 797-810.

Stephenson, S.N., and P.S. Herendeen. 1986. Short-term drought effects on the alvar communities of Drummond Island, Michigan. *Michigan Botanist* 25: 16-27.

For a full list of references used to create this description, please refer to the natural community abstract for limestone bedrock glade.

Granite Bedrock Glade

Global/State Rank: G3G5/S2

Overview

Granite bedrock glade consists of an open forested or savanna community found where knobs of granitic bedrock types are exposed at the surface. The sparse vegetation consists of scattered open-grown trees, scattered shrubs or shrub thickets, and a partial turf of herbs, grasses, sedges, mosses, and lichens. Granite bedrock glades typically occupy areas of steep to stair-stepped slopes, with short cliffs, and exposed knobs of bedrock. The community occurs in the western Upper Peninsula with primary concentrations in Marquette, Baraga, and Dickinson Counties.

Landscape Context

A broad range of igneous and metamorphic rocks, including gneiss, schist, granite, and quartzite, are often loosely referred to as “granitic” or “granite.” Granite bedrock glade occurs on granite, schist, gabbro, gneiss, slate, “iron formations,” greenstones, and a diversity of other resistant igneous and metamorphic rock types of the Michigamme Highlands that formed during the Precambrian Era, approximately 600 to 3,500 million years ago. These rock types form large rounded ridges that were shaped and polished by the continental ice sheets about 10,000 years ago.

The community occurs both inland and adjacent to the Lake Superior shoreline. Granitic bedrock glades typically occupy areas of steep to stair-stepped slopes, with short cliffs, exposed bedrock knobs, and talus slopes occurring at the base of the bedrock exposures. The forest types surrounding granitic bedrock are typically dry-mesic northern forest or mesic northern forest. Along the Lake Superior shoreline, boreal forest is a common associate and in localized areas, granite bedrock glade can occur adjacent to granite bedrock lakeshore, granite lakeshore cliff, volcanic cobble shore, and sand and gravel beach.

Soils

Soil development is generally restricted to cracks and depressions within the rock, where plant debris and sand and gravel resulting from mechanical and biological weathering of the bedrock can accumulate. These soils are typically very shallow and low in nutrients. Thin soils are typically 1 to 4 cm (0.4 to 1.6 in) deep, strongly acidic, and characterized by low moisture availability. Exfoliation of rock slabs and frost wedging is characteristic of granite and contributes to soil formation. Numerous large boulders, slabs, and small granitic rocks occur scattered throughout the glades, and talus slopes occur at the base of many bedrock exposures.

Natural Processes

Windthrow, desiccation, fire, and exfoliation of rock slabs are all important natural processes for bedrock glade communities. Windthrown trees are common as a result of thin soils and strong winds associated with Lake Superior. Thin soils, cold winter temperatures, steady winds, and summer droughts make vegetation especially prone to desiccation. Rain that lands on sloping bedrock outcrops quickly runs off to lower elevation areas, further contributing to dry conditions and removing accumulated plant debris and small rock debris that could otherwise initiate soil formation. Glades are subject to fires from both lightning and human sources. Both white pine and red pine form a supercanopy and are prime targets for lightning strikes associated with Lake Superior storms. The open structure and elevated position of glades make them ideal places for historic and modern human gathering, which were and are associated with escaped campfires.

Vegetation

Vegetation goes through a slow succession from lichens and mosses in moist rock depressions to gradual establishment of mats of herbaceous vascular plants. As soil gradually develops, these mats begin supporting localized clumps of shrubs and small trees. Dominant trees of the open canopy include stunted red oak (*Quercus rubra*) and white pine (*Pinus strobus*). Other common trees, occurring in the scattered and low canopy and also as saplings in the understory, include red pine (*P. resinosa*), quaking aspen (*Populus tremuloides*), big-toothed aspen (*P. grandidentata*), and paper birch (*Betula papyrifera*). Common shrubs include low sweet blueberry (*Vaccinium angustifolium*), Canada blueberry (*V. myrtilloides*), bearberry (*Arctostaphylos uva-ursi*), common juniper (*Juniperus communis*), serviceberry (*Amelanchier interior*), wild red raspberry (*Rubus strigosus*), smooth sumac (*Rhus glabra*), choke cherry (*Prunus virginiana*), pin cherry (*P. pensylvanica*), and bush honeysuckle (*Diervilla lonicera*). Among the commonly occurring forbs are cow-wheat (*Melampyrum lineare*), slender ladies'-tresses (*Spiranthes lacera*), large-leaved aster (*Aster macrophyllus*), jumpseed (*Polygonum virginianum*), western smartweed (*Polygonum douglasii*), wild strawberry (*Fragaria virginica*), and harebell (*Campanula rotundifolia*). Commonly occurring graminoids include Pennsylvania sedge (*Carex pensylvanica*), poverty grass (*Danthonia spicata*), hair grasses (*Deschampsia flexuosa* and *D. cespitosa*), rice grass (*Oryzopsis pungens*), and panic grasses (*Panicum columbianum*, *P. depauperatum*, and *P. linearifolium*). Common ferns include rusty woodsia (*Woodsia ilvensis*), marginal woodfern (*Dryopteris marginalis*), spinulose woodfern (*D. carthusiana*), common polypody (*Polypodium virginianum*), maidenhair spleenwort (*Asplenium trichomanes*), and bracken fern (*Pteridium aquilinum*). Areas of exposed bedrock are dominated by a diverse array of lichens (e.g., *Cladina* spp.) and mosses (e.g., *Polytrichum* spp.).

Noteworthy Animals

Ants are quite abundant in this dry, thin-soiled environment. American black bears (*Ursus americanus*) use this habitat, possibly because of the abundant ants, other insects, and wild fruit.

Rare Plants

Dryopteris filix-mas (male fern, state special concern)
Dryopteris fragrans (fragrant cliff woodfern, state special concern)
Opuntia fragilis (fragile prickly-pear, state endangered)
Ribes oxycanthoides (northern gooseberry, state special concern)
Woodsia alpina (northern woodsia, state endangered)

Rare Animals

Falco columbarius (merlin, state threatened)
Falco peregrinus (peregrine falcon, state endangered)
Haliaeetus leucocephalus (bald eagle, state special concern)

Biodiversity Management Considerations

The thin soils and lichen cover are easily destroyed by off-road vehicles or excessive foot traffic. Many seasonal cabins are built within the glades, resulting in major degradation, including the introduction of non-native plants. Fill is often introduced for septic systems, also increasing habitat for invasive plants. Invasive plants that threaten the diversity and community structure in granite bedrock glade include sweet cherry (*Prunus avium*), sheep sorrel (*Rumex acetosella*), common mullein (*Verbascum thapsus*), spotted knapweed (*Centaurea maculosa*), ox-eye daisy (*Chrysanthemum leucanthemum*), hawkweeds (*Hieracium* spp.), common St. John's-wort (*Hypericum perforatum*), timothy (*Phleum pratense*), Canada bluegrass (*Poa compressa*), and Kentucky bluegrass (*P. pratensis*). Monitoring and control efforts to detect and remove invasive plants are critical to the long-term viability of bedrock glades. Maintaining a mature,

unfragmented forested buffer around bedrock glades may help limit the local seed source for invasive species distributed by wind or birds.

Open conditions within glades can be maintained by allowing wildfires to move through the community where safety and other conditions permit. Prescribed fire management of adjacent dry-mesic forests should include areas of bedrock glade when feasible.

Variation

Species composition may vary with bedrock type and aspect.

Similar Natural Communities

Northern bald, granite bedrock lakeshore, granite cliff, granite lakeshore cliff, volcanic bedrock glade, volcanic bedrock lakeshore, volcanic cliff, sandstone bedrock lakeshore, sandstone cliff, and dry-mesic northern forest.

Relevant Literature

- Albert, D.A., P. Comer, D. Cuthrell, D. Hyde, W. MacKinnon, M. Penskar, and M. Rabe. 1997. The Great Lakes bedrock lakeshores of Michigan. Michigan Natural Features Inventory, Lansing, MI. 218 pp.
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- LaBerge, G.L. 1994. *Geology of the Lake Superior region*. Geoscience Press, Phoenix, AZ. 313 pp.
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Volcanic Bedrock Glade

Global/State Rank: GU/S2

Overview

Volcanic bedrock glade consists of an open forested or savanna community found where basaltic bedrock and conglomerates are exposed. The sparse vegetation consists of scattered open-grown trees, scattered shrubs or shrub thickets, and a partial turf of herbs, grasses, sedges, mosses, and lichens. The community occurs in the western Upper Peninsula on Isle Royale and the Keweenaw Peninsula, extending southwest into Houghton, Ontonagon, and Gogebic Counties.

Landscape Context

Basalt and conglomerate bedrock are typically tilted about 40 degrees from horizontal, creating a landscape where vegetation cover is often sparse and unstable. Volcanic bedrock glades typically occupy areas of steep to stair-stepped slopes, with short cliffs and exposed bedrock knobs. The community occurs both inland and adjacent to the Lake Superior shoreline. The forest types adjacent to volcanic bedrock glade are typically dry-mesic northern forest or mesic northern forest and along the Lake Superior shoreline, boreal forest. In addition to boreal forest, nearshore volcanic bedrock glade is associated with volcanic bedrock lakeshore, volcanic cobble shore, volcanic lakeshore cliff, and sand and gravel beach.

Soils

Continental glacial ice sheets from about 10,000 years ago left large areas of bedrock devoid of soil. Some organic soil has developed in pockets and cracks within the volcanic rock, but there are also large areas with no soil, where lichens and mosses are the predominant vegetation. The prevalent rock formations are Precambrian-age Copper Harbor Conglomerates and Portage Lake Volcanics. The volcanic rock formed from vast sheets of flowing lava, interbedded with thin layers of conglomerate, which consisted of both pebbles and cobbles. Basalt, the predominant bedrock of the glades, ranges from medium acid to mildly alkaline in pH. Arctic-alpine vegetation is more common on the conglomerate and on volcanic rock characterized by many vesicles (vesicular basalt), which have more irregularities and cracks for soil development and root anchoring, than on massive basalt, which typically lacks vesicles.

Natural Processes

Erosion, windthrow, desiccation, and fire are all important natural processes influencing volcanic bedrock glade communities. Rock erosion results in accumulation of loose rocks (talus) at the base of slopes. Windthrown trees are common as a result of thin soils and strong winds associated with Lake Superior. Thin soils, cold winter temperatures, steady winds, and summer droughts make vegetation especially prone to desiccation. Rain that lands on sloping bedrock outcrops quickly runs off to lower elevation areas, further contributing to dry conditions and removing accumulated plant debris that could otherwise initiate soil formation. Glades are subject to fires from both lightning and human sources. Both white pine (*Pinus strobus*) and red pine (*P. resinosa*) form a supercanopy and are prime targets for lightning strikes associated with Lake Superior storms. The open structure and elevated position above Lake Superior of glades make them ideal places for historic and modern human gathering, which were and are associated with escaped campfires.

Vegetation

Vegetation cover ranges from nearly absent on exposed outcrops of basalt or conglomerate to dense where soil has accumulated on talus or in joints and depressions. The scattered overstory is dominated by white pine, red pine, jack pine (*P. banksiana*), paper birch (*Betula papyrifera*), quaking aspen (*Populus tremuloides*), white spruce (*Picea glauca*), balsam fir (*Abies balsamea*), and red oak (*Quercus rubra*). Common shrubs include bearberry (*Arctostaphylos uva-ursi*), creeping juniper (*Juniperus horizontalis*), common juniper (*J. communis*), trailing arbutus (*Epigaea repens*), wild rose (*Rosa acicularis*), soapberry (*Shepherdia canadensis*), low sweet blueberry (*Vaccinium angustifolium*), Canada blueberry (*V. myrtilloides*), Canada bilberry (*V. membranaceum*), thimbleberry (*Rubus parviflorus*), and serviceberry (*Amelanchier* spp.). Common grasses are poverty grass (*Danthonia spicata*), hair grasses (*Deschampsia flexuosa* and *D. cespitosa*), and rough-leaved rice grass (*Oryzopsis asperifolia*). Common forbs include cow-wheat (*Melampyrum lineare*), twinflower (*Linnaea borealis*), harebell (*Campanula rotundifolia*), wild strawberry (*Fragaria virginiana*), yarrow (*Achillea millefolium*), bastard toadflax (*Comandra umbellata*), red honeysuckle (*Lonicera dioica*), large-leaved aster (*Aster macrophyllus*), and Canada mayflower (*Maianthemum canadense*). Bracken fern (*Pteridium aquilinum*) can also be common. Lichens (e.g., *Cladina* spp. and *Usnea* spp.) and mosses (e.g., *Polytrichum* spp.) are typically abundant to locally dominant.

Noteworthy Animals

Ants are quite abundant in this dry, thin-soiled environment. American black bears (*Ursus americanus*) use the habitat, possibly because of the abundance of ants, other insects, and wild fruit.

Rare Plants

Antennaria rosea (rosy pussytoes, presumed extirpated from Michigan)
Arnica cordiformis (heart-leaved arnica, state endangered)
Castilleja septentrionalis (pale Indian paintbrush, state threatened)
Cerastium brachypodum (shortstalk chickweed, state threatened)
Crataegus douglasii (Douglas's hawthorn, state special concern)
Cryptogramma acrostichoides (American rock-brake, state threatened)
Diphasiastrum alpinum (alpine clubmoss, presumed extirpated from Michigan)
Lactuca pulchella (blue lettuce, presumed extirpated from Michigan)
Phacelia franklinii (Franklin's phacelia, state threatened)

Rare Animals

Alces americanus (moose, state special concern)
Falco peregrinus (peregrine falcon, state endangered)
Lycaeides idas nabokovi (northern blue butterfly, state threatened)

Biodiversity Management Considerations

The thin soils and lichen cover are easily destroyed by off-road vehicles or excessive foot traffic. Many seasonal cabins are built within the glades, resulting in major degradation, including the introduction of non-native plants. Fill is often introduced for septic systems, also increasing habitat for invasive plants. Invasive plants that threaten the diversity and community structure in volcanic bedrock glades include spotted knapweed (*Centaurea maculosa*), ox-eye daisy (*Chrysanthemum leucanthemum*), Canada bluegrass (*Poa compressa*), Kentucky bluegrass (*P. pratensis*), sheep sorrel (*Rumex acetosella*), and hawkweeds (*Hieracium* spp.).

Monitoring and control efforts to detect and remove these and other invasive species will help maintain the native biodiversity of volcanic bedrock glade and surrounding natural communities.

Given that the thin soils and slow-growing lichen and moss cover are sensitive to anthropogenic disturbance and recover slowly, conservation efforts should focus on preserving the ecological integrity of existing high-quality volcanic bedrock glades. Open conditions within glades can be maintained by allowing wildfires to move through the community where safety and other conditions permit. Prescribed fire management of adjacent dry-mesic forests should include areas of bedrock glade when feasible.

Variation

Recent studies indicate that volcanic bedrock glades on Isle Royale are often dominated by white spruce and balsam fir, although quaking aspen may dominate more recently burned sites.

Similar Natural Communities

Northern bald, granite bedrock glade, limestone bedrock glade, dry-mesic northern forest, boreal forest, volcanic bedrock lakeshore, and granite bedrock lakeshore. Northern bald is a similar plant community occurring on the extreme exposed bedrock at the highest elevations on the Keweenaw Peninsula and stretching southwest into Gogebic County.

Relevant Literature

- Albert, D.A., P. Comer, D. Cuthrell, D. Hyde, W. MacKinnon, M. Penskar, and M. Rabe. 1997. The Great Lakes bedrock lakeshores of Michigan. Michigan Natural Features Inventory, Lansing, MI. 218 pp.
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- Reschke, C. 1985. Vegetation of the conglomerate rock shoreline of the Keweenaw Peninsula, northern Michigan. M.S. thesis. University of Wisconsin, Madison, WI. 118 pp.
- Slavick, A.D., and R.A. Janke. 1987. The vascular flora of Isle Royale National Park. Michigan Botanist 26: 91-134.

For a full list of references used to create this description, please refer to the natural community abstract for volcanic bedrock glade.

Northern Bald

Global/State Rank: GU/S1

Overview

Northern bald is a low shrub and herbaceous community with scattered flagged trees and trees distorted into a krummholz growth form by branch breakage due to heavy snow, thick ice, and extreme winds off Lake Superior. Northern balds are restricted to large escarpments of volcanic bedrock ridges and are characterized by sparse vegetation, areas of exposed bedrock, and thin, slightly acidic soils. The community is also referred to as krummholz ridgetop.

Landscape Context

Northern balds are positioned along the top of high volcanic bedrock escarpments that rise above the adjacent hilly landscape. The escarpments consist of Precambrian-age Keweenaw Series bedrock, either basalts or basaltic conglomerates, occurring on Isle Royale and extending from near the northeastern tip of the Keweenaw Peninsula to the southwest into Houghton, Ontonagon, and Gogebic Counties. The surrounding forest types include dry-mesic northern forest and mesic northern forest.

Soils

The soils are thin, slightly acid sandy soil over bedrock. Areas of exposed bedrock that lack soil development are common. Thin organic sediments accumulate in joints, cracks, and depressions and are important substrates for vegetation.

Natural Processes

Extreme winds and ice storms characterize the northern bald community, causing trees in the scattered overstory to become flagged, a condition in which freezing winds kill branches on the windward side of the tree and the upper branches grow mainly from the leeward side of the tree, like a flag blowing from a flagpole. In addition, the harsh conditions result in some trees developing a krummholz form, a stunted, twisted condition common to subarctic or subalpine tree lines. The high winds and lack of soil development result in severe plant desiccation, despite the year-round occurrence of fog off Lake Superior. Although the thin soils promote extremely droughty conditions, the absence of full-grown trees is induced chiefly by the exposed ridge-top position, which promotes winter desiccation, ice and snow abrasion, and breakage by high winds. The lack of soil development and droughty conditions are further maintained on these bedrock ridge tops by rapid runoff following snow melt and rain events. Lastly, portions of the bedrock escarpment regularly slough off, forming talus slopes along the base of cliffs and exposing fresh, bare rock substrates.

Vegetation

Vegetation is scattered with areas of exposed bedrock common. Dominant tree species in the scattered, flagged overstory include white pine (*Pinus strobus*), red oak (*Quercus rubra*), and big-toothed aspen (*Populus grandidentata*). Balsam fir (*Abies balsamea*), white spruce (*Picea glauca*), and northern white-cedar (*Thuja occidentalis*) may also be common. Dominant shrubs include bearberry (*Arctostaphylos uva-ursi*), common juniper (*Juniperus communis*), staghorn sumac (*Rhus typhina*), and low sweet blueberry (*Vaccinium angustifolium*). Additional shrubs include creeping juniper (*Juniperus horizontalis*) and choke cherry (*Prunus virginiana*). Fern diversity is high with the most common ferns being rusty woodsia (*Woodsia ilvensis*) and maidenhair spleenwort (*Asplenium trichomanes*). Other common ferns include Braun's holly-fern

(*Polystichum braunii*), northern holly-fern (*P. lonchitis*), and male fern (*Dryopteris filix-mas*, state special concern). Common ground flora include poverty grass (*Danthonia spicata*), wild strawberry (*Fragaria virginiana*), western smartweed (*Polygonum douglasii*), prairie cinquefoil (*Potentilla arguta*), three-toothed cinquefoil (*P. tridentata*), early saxifrage (*Saxifraga virginensis*), ground cedar (*Diphasiastrum tristachyum*), and sand violet (*Viola adunca*). The fern ally sand club moss (*Selaginella rupestris*) is also common in some sites.

Northern balds may contain several vegetation zones. The ridge top is typically open, with only herbs and shrubs, while at slightly lower elevations, where winds may be less severe, dwarfed trees occur. Many of the ferns and rare plants, such as small blue-eyed Mary (*Collinsia parviflora*, state threatened), are concentrated along the south edge of escarpments, where there is typically a cliff. Talus slopes form along the base of the cliff. One rare plant, redstem ceanothus (*Ceanothus sanguineus*, state threatened), grows almost exclusively on the talus.

Noteworthy Animals

The steep rock ridges associated with northern bald are important habitat for raptors.

Rare Plants

Ceanothus sanguineus (redstem ceanothus, state threatened)
Collinsia parviflora (small blue-eyed Mary, state threatened)
Dryopteris filix-mas (male fern, state special concern)
Ranunculus rhomboideus (prairie buttercup, state threatened)
Ribes oxycanthoides (northern gooseberry, state special concern)

Rare Animals

Falco columbarius (merlin, state threatened)

Biodiversity Management Considerations

Because of the thin soils, which cause shallow rooting, and harsh conditions, the vegetation of northern balds can be extremely slow to recover or reestablish following excessive trampling. Trails through balds should be minimized or avoided. Roads and trails also provide routes for invasive plants to establish. Invasive plants that threaten the diversity and community structure of northern balds include spotted knapweed (*Centaurea maculosa*), ox-eye daisy (*Chrysanthemum leucanthemum*), Canada bluegrass (*Poa compressa*), sheep sorrel (*Rumex acetosella*), and hawkweeds (*Hieracium* spp.). Monitoring and control efforts to detect and remove invasive species are critical to the long-term viability of northern balds. Maintaining a mature, unfragmented forested buffer around balds may help limit the local seed source for invasive species distributed by wind or birds. Use of the escarpments for rock climbing has the potential to degrade vegetation along the cliff edge. Snowmobiling through northern balds also threatens vegetation.

Variation

The northern balds of the Keweenaw Peninsula, located on volcanic conglomerate bedrock, appear to support a more diverse flora than those on basalt to the southwest.

Similar Natural Communities

Granite bedrock glade, volcanic bedrock glade, limestone bedrock glade, granite cliff, limestone cliff, sandstone cliff, and volcanic cliff.

Relevant Literature

- Albert, D.A., P. Comer, D. Cuthrell, D. Hyde, W. MacKinnon, M. Penskar, and M. Rabe. 1997. The Great Lakes bedrock lakeshores of Michigan. Michigan Natural Features Inventory, Lansing, MI. 218 pp.
- Bornhorst, T.J., and W.I. Rose. 1994. Self-guided geological field trip to the Keweenaw Peninsula, Michigan. Proceedings of the Institute on Lake Superior Geology. Volume 40, Part 2. 185 pp.
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COBBLE SHORE COMMUNITIES

Limestone Cobble Shore

Global/State Rank: G2G3/S3

Overview

Limestone cobble shore occurs along the northern Lake Michigan and Lake Huron shorelines. The community is typically sparsely vegetated, because cobbles cover most of the surface and storm waves prevent the development of a diverse, persistent plant community.

Landscape Context

Cobble shores are most extensive along the Niagaran Cuesta, a gentle bedrock plain that runs along the north shore of Lake Michigan, Lake Huron, and Georgian Bay, from the Door Peninsula in northern Wisconsin to the Bruce Peninsula of Ontario. Cobble shores are also common on many of the northern islands of all three of these large water bodies. Most of the cobbles were part of Silurian and Ordovician limestone reefs that formed in the shallow seas of the Michigan Basin. Farther south, in Presque Isle and Alpena counties in northern Lower Michigan, the marine deposits are Devonian-age limestones, which were also formed in shallow seas. Cobble shores often occur interspersed with limestone pavement and adjacent to coastal fen, Great Lakes marsh, boreal forest, limestone bedrock glade, and alvar grassland.

Soils

The size of the cobbles and both the depth and texture of underlying sediments vary greatly and can affect both the diversity and stability of the plant community. While most of the beach surface consists of cobbles of varying size, the underlying parent material is either limestone bedrock or fine-textured till. Between the cobbles there is rock, mineral, or organic soils. Soil texture is typically heavy clay or loam, but in some areas these fine-textured soils are overlain with a thin veneer of sand. Organic sediments can accumulate to 5 cm or more in protected inner portions of the shore. Regardless of the soil texture, pH is mildly to moderately alkaline. Deep accumulations of large cobbles tend to be quite dry and are nearly unvegetated. In contrast, shallow accumulations of small gravel and cobbles, especially when mixed with a moist sandy substrate, tend to support denser and more diverse plant cover.

Natural Processes

Cobble beaches are a dynamic environment of wind and waves. Storm waves regularly disturb the beaches, reconfiguring the substrate and removing fine sediments. During the winter, shoreline ice freezes to the bottom and is plucked loose during storms, further eroding and modifying the bottom. Intense winter storms can result in the formation of storm beaches, in which cobble-sized rocks are piled upon each other. Storm beaches can accumulate cobbles up to several meters or more in depth. Longer term, cyclic fluctuations of Great Lakes water levels significantly influence vegetation patterns of limestone cobble shores, with vegetation becoming well established during low-water periods and most species dying back or disappearing during high-water periods.

Vegetation

Among the frequently encountered plants are dwarf Canadian primrose (*Primula mistassinica*), harebell (*Campanula rotundifolia*), low calamint (*Calamintha arkansana*), Kalm's lobelia

(*Lobelia kalmii*), silverweed (*Potentilla anserina*), grass-of-Parnassus (*Parnassia glauca*), false asphodel (*Tofieldia glutinosa*), ticklegrass (*Agrostis hyemalis*), sedge (*Carex viridula*), rushes (*Juncus balticus* and *J. dudleyi*), golden-seeded spike-rush (*Eleocharis elliptica*), beak-rush (*Rhynchospora capillacea*), small fringed gentian (*Gentianopsis procera*), Indian paintbrush (*Castilleja coccinea*), Ohio goldenrod (*Solidago ohioensis*), variegated scouring rush (*Equisetum variegatum*), common boneset (*Eupatorium perfoliatum*), white camas (*Zigadenus glaucus*), grass-leaved goldenrod (*Euthamia graminifolia*), slender bog arrow-grass (*Triglochin palustris*), Kalm's St. John's-wort (*Hypericum kalmianum*), and balsam poplar (*Populus balsamifera*).

Limestone cobble shore gradually grades from open, unvegetated cobbles closer to the water's edge to a more vegetated herbaceous zone farther inland. Within the ground cover there are often shrub-sized balsam poplar, tamarack (*Larix laricina*), paper birch (*Betula papyrifera*), and northern white-cedar (*Thuja occidentalis*). Recurring high water does not allow these trees to reach maturity, but just inland of the open cobble shore is typically a dense thicket of upland trees and shrubs, including balsam poplar, tamarack, northern white-cedar, paper birch, quaking aspen (*Populus tremuloides*), and white spruce (*Picea glauca*), along with soapberry (*Shepherdia canadensis*), tag alder (*Alnus rugosa*), and shrubby cinquefoil (*Potentilla fruticosa*).

Surveys of cobble shores have been few, but many of the species listed above are common plants of the calcium-rich shoreline of the northern Great Lakes. Many of the species characteristic of either the nearby bedrock shore, coastal fen, or northern fen communities can be found growing scattered along cobble shores, including many of the rare species.

Noteworthy Animals

The high-energy environment of the cobble shore appears to provide little stable habitat for terrestrial insects, but the sediments and rock surfaces are extremely rich in aquatic invertebrates. Limestone cobble shores share many species with cold, fast-flowing streams, including midges (*Chironomidae*), stoneflies (*Perlidae*), and mayflies (*Ephemeroptera*). In spring, migrating warblers feed heavily on the midges that settle in the northern white-cedar that ring the shoreline.

Rare Plants

Adlumia fungosa (climbing fumitory, state special concern)
Cacalia plantaginea (prairie Indian-plantain, state special concern)
Carex atratiformis (sedge, state threatened)
Carex richardsonii (Richardson's sedge, state special concern)
Carex scirpoides (bulrush sedge, state threatened)
Empetrum nigrum (black crowberry, state threatened)
Iris lacustris (dwarf lake iris, federal/state threatened)
Pinguicula vulgaris (butterwort, state special concern)
Scutellaria parvula (small skullcap, state threatened)
Solidago houghtonii (Houghton's goldenrod, state threatened)
Tanacetum huronense (Lake Huron tansy, state threatened)

Rare Animals

Catinella exile (Pleistocene catinella, state threatened)
Charadrius melodus (piping plover, federal/state endangered)
Emydoidea blandingii (Blanding's turtle, state special concern)
Euconulus alderi (land snail, state threatened)
Gastrocopta holzingeri (lambda snaggletooth, endangered)
Pyrgulopsis letsoni (gravel pyrg, state special concern)
Sistrurus c. catenatus (eastern massasauga, federal candidate species and state special concern)

Sterna caspia (Caspian tern, state threatened)
Sterna hirundo (common tern, state threatened)
Vallonia gracilicosta albula (land snail, state endangered)
Vertigo elatior (tapered vertigo, state special concern)

Biodiversity Management Considerations

The extremely dynamic energy of this environment makes it less easily damaged than many other natural communities, but its fauna remains vulnerable to off-road vehicles and pets, primarily dogs. Some of the invasive species that have potential to colonize the community include spotted knapweed (*Centaurea maculosa*), ox-eye daisy (*Chrysanthemum leucanthemum*), common St. John's-wort (*Hypericum perforatum*), Canada bluegrass (*Poa compressa*), Kentucky bluegrass (*P. pratensis*), hawkweeds (*Hieracium* spp.), sheep sorrel (*Rumex acetosella*), garden tansy (*Tanacetum vulgare*), common mullein (*Verbascum thapsus*), and glossy buckthorn (*Rhamnus frangula*). Monitoring and control efforts to detect and remove invasives before they become well established will help protect biodiversity of limestone cobble shore and other adjacent natural communities. Eliminating illegal off-road vehicle activity is a primary means of protecting the ecological integrity of limestone cobble shore.

Variation

The size of the cobbles and both the depth and texture of underlying sediments vary greatly and can affect both diversity and stability of the plant community.

Similar Natural Communities

Limestone bedrock lakeshore, sand and gravel beach, coastal fen, volcanic cobble shore, sandstone cobble shore, and Great Lakes marsh.

Relevant Literature

- Albert, D.A. 2007. Natural community abstract for limestone cobble shore. Michigan Natural Features Inventory, Lansing, MI. 6 pp.
- Albert, D.A., P. Comer, D. Cuthrell, D. Hyde, W. MacKinnon, M. Penskar, and M. Rabe. 1997. The Great Lakes bedrock lakeshores of Michigan. Michigan Natural Features Inventory, Lansing, MI. 218 pp.
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- Reed, R.C., and J. Daniels. 1987. Bedrock geology of northern Michigan. State of Michigan Department of Natural Resources. Map: 1: 500,000.

For a full list of references used to create this description, please refer to the natural community abstract for limestone cobble shore.

Sandstone Cobble Shore

Global/State Rank: G2G3/S2

Overview

Sandstone cobble shore is a sparsely vegetated community that occupies the edges of Lake Superior, predominantly occurring in coves and gently curving bays in association with bedrock cliff, bedrock outcrop, sandstone bedrock lakeshore, and sand and gravel beach. These cobble shores may be nearly level and support a diversity of herbaceous plants where they border sand and gravel beach or relatively steep and terraced in coves between bedrock outcrops, with vegetation mostly limited to the highest cobble beach ridge, where scattered trees and shrubs are dominant. Sandstone cobble shore is dominated by flat, round-sided sandstones that move readily when subject to intense wave action, limiting soil development and vegetation establishment.

Landscape Context

Sandstone cobble shore occurs along the edges of Lake Superior as part of the Copper Harbor Conglomerate, Jacobsville Sandstone, and Nonesuch and Freda Formations. This type of cobble shore includes a combination of siltstones and shales in addition to sandstones, and is found along the shores of Lake Superior in the United States and Canada, including Michigan, Minnesota, Wisconsin, and Ontario. In Michigan, sandstone cobble shore occurs at the east end of Pictured Rocks National Lakeshore, along the Keweenaw Peninsula and Point Abbaye, and within and near Porcupine Mountains Wilderness State Park.

Sandstone cobble shores are typically bordered along their inland margin by boreal forest, mesic northern forest, and occasionally by forested wetlands. Along the shoreline, they may be interspersed with areas of sandstone bedrock lakeshore, sandstone lakeshore cliff, granite bedrock lakeshore, granite lakeshore cliff, volcanic bedrock lakeshore, volcanic cobble shore, and sand and gravel beach.

Soils

Little or no soil development occurs on sandstone cobble shore. The few plants that establish are rooted in sand and gravel deposits under the coarse cobble. The size of the weathered and eroded sandstone cobbles ranges from 2 to 3 cm (0.75 to 1.0 in) in diameter to over 20 cm (8 in) in diameter, and large sandstone and conglomerate boulders or slabs can be common.

Natural Processes

Storm waves, ice scour, and desiccation are the primary forms of natural disturbance. The flat-sided sandstones are easily moved and rearranged by storm waves and ice movement, which form and remove terraces, uproot and bury plants, and limit soil development. In addition to a lack of soil, plant establishment in deep cobble is limited by desiccating conditions during summer droughts as a result of full exposure to sun and wind. Groundwater seepage, storm waves, and streams, both perennial and intermittent, provide a source of moisture for vegetation in some areas of the community. Windthrow is common along the inland forested edge due to strong winds associated with Lake Superior storms.

Vegetation

Sandstone cobble shore is a sparsely vegetated community. The community may occur as a steep terraced ridge in protected coves and gently curving bays between bedrock shorelines or cliffs, or occasionally as nearly level, frequently inundated cobble beaches with large stranded slabs of

sandstone and conglomerate bedrock. On steeply terraced sandstone cobble shores, very few plants are able to establish except along the upper beach ridge, in moist areas of groundwater seepage, and along small streams. Plants growing along the upper cobble beach ridge include a variety of scattered trees and shrubs such as paper birch (*Betula papyrifera*), northern white-cedar (*Thuja occidentalis*), quaking aspen (*Populus tremuloides*), highbush cranberry (*Viburnum opulus* var. *americanum*), thimbleberry (*Rubus parviflorus*), and raspberries (*Rubus* spp.). Species occurring in the wet areas of steep sandstone cobble shore include fringed sedge (*Carex crinita*), water-hemlock (*Cicuta maculata*), common horsetail (*Equisetum arvense*), rattlesnake grass (*Glyceria canadensis*), jewelweed (*Impatiens capensis*), northern bugleweed (*Lycopus uniflorus*), and common skullcap (*Scutellaria galericulata*). On nearly level, frequently inundated sandstone cobble shore common plant species include water plantain (*Alisma plantago-aquatica*), sedge (*Carex viridula*), water-hemlocks (*C. bulbifera* and *C. maculata*), grass-leaved goldenrod (*Euthamia graminifolia*), common boneset (*Eupatorium perfoliatum*), joe-pye-weed (*E. maculatum*), jewelweed, common water horehound (*Lycopus americanus*), northern bugleweed, smartweeds (*Polygonum* spp.), pondweeds (*Potamogeton* spp.), rushes (*Juncus* spp.), common arrowhead (*Sagittaria latifolia*), and water parsnip (*Sium suave*). The large sandstone and conglomerate slabs stranded along the cobble shore support a similar species composition as that found on sandstone bedrock lakeshore, including hair grass (*Deschampsia cespitosa*), upland white goldenrod (*Solidago ptarmicoides*), Gillman's goldenrod (*S. simplex*), balsam ragwort (*Senecio pauperculus*), and wild strawberry (*Fragaria virginiana*).

Noteworthy Animals

The high-energy environment of the cobble shore appears to provide little stable habitat for terrestrial insects, but the sediments and rock surfaces are sometimes rich in aquatic invertebrates.

Rare Plants

None documented.

Rare Animals

None documented.

Biodiversity Management Considerations

Off-road vehicles (ORVs) can destroy vegetation growing in sandstone cobble shores, further reducing diversity. Eliminating illegal ORV activity is a primary means of protecting sandstone cobble shores. Maintaining a forested buffer will help prevent soil erosion and runoff into the community and may help reduce the local seed source of non-native invasive plants. Like other natural communities, monitoring and control efforts to detect and remove invasive plants will help protect the ecological integrity of sandstone cobble shore. Several invasive species that may have potential to colonize the community include reed (*Phragmites australis*), glossy buckthorn (*Rhamnus frangula*), and multiflora rose (*Rosa multiflora*).

Variation

Community structure and species composition are strongly influenced by the sizes and types of cobble, steepness of shoreline slope, and presence or absence of terracing, groundwater seepage, and streams. Geological differences in sandstone bedrock along Lake Superior cause variability in cobble texture and erosion resistance, which in turn influences soil development and vegetation establishment. Sandstone cobble shore also includes cobbles formed from finer siltstone and shale. Siltstones occur along the west shore of the Keweenaw Peninsula, and small exposures of shale occur farther west along the Porcupine Mountains' shoreline. Low shale ledges are also present along the southwestern shoreline of Lake Huron, but no well developed cobble shores are known from this area.

Similar Natural Communities

Volcanic cobble shore, limestone cobble shore, sandstone bedrock lakeshore, sandstone lakeshore cliff, and sand and gravel beach.

Relevant Literature

- Albert, D.A., P. Comer, D. Cuthrell, D. Hyde, W. MacKinnon, M. Penskar, and M. Rabe. 1997. The Great Lakes bedrock lakeshores of Michigan. Michigan Natural Features Inventory, Lansing, MI. 218 pp.
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Volcanic Cobble Shore

Global/State Rank: G4G5/S3

Overview

Volcanic cobble shore occurs along Lake Superior, predominantly in coves and gently curving bays between rocky points. These mostly unvegetated shores are often terraced, with the highest cobble beach ridge typically supporting a shrub zone several meters above Lake Superior.

Landscape Context

Volcanic cobble shore occurs in the northern Great Lakes region of the United States and Canada, ranging across the Lake Superior shoreline of Michigan, Minnesota, and Ontario. This cobble shore type is derived primarily from the erosion of the Copper Harbor Conglomerates, but includes weathered and eroded sandstone rock derived from other volcanic formations of Precambrian age, including the Portage Lake Volcanics. These shores, which are regularly disturbed by wave action and winter ice movements from the lake, are much steeper than most other cobble beaches encountered on the lower Great Lakes. Most of the shore has little or no vegetation, probably due to regular disturbance by storm waves, which move and reshape the cobble. The highest beach ridge, where scattered shrub vegetation typically establishes, is disturbed only infrequently by the most severe storm waves.

Volcanic cobble shore is typically bordered along its inland edge by boreal forest, dry-mesic northern forest, or mesic northern forest, and occasionally by volcanic bedrock glade. Where streams flow through the community, northern shrub thicket may occasionally border its upper edge. Along the shoreline, volcanic cobble shore is interspersed with areas of volcanic bedrock lakeshore, volcanic lakeshore cliff, and sand and gravel beach.

Soils

Little or no soil development occurs on volcanic cobble shore. The few plants that establish probably root in sand and gravel deposits under the cobble, which can be more than a meter in depth. On the Keweenaw Peninsula, the size of the cobbles ranges from 2 to 3 cm (0.75 to 1 in) in diameter to over 20 cm (8 in) in diameter, and large sections of the shoreline consist of similar-sized cobbles. The largest cobbles are located at the extreme east end of the peninsula, where the cobble shoreline is steepest and storm waves the most severe.

Natural Processes

Storm waves, erosion by ice-blocks, and desiccation are the primary forms of natural disturbance and act to limit vegetation establishment. Storm waves and ice movement can rearrange cobble shore, form and remove terraces, and uproot and bury plants. Plant establishment in deep cobble is limited by desiccating conditions from full exposure to sun and wind and a lack of moisture during summer droughts. Groundwater seepage, storm waves, and streams, both perennial and intermittent, provide a source of moisture for vegetation in some areas of the community during dry periods. Windthrow is common along the forested edge due to strong winds associated with Lake Superior storms.

Vegetation

Volcanic cobble shore is a sparsely vegetated community. On most sites, the lower beach is free of vegetation due to wave and ice action. Most vegetation is concentrated on the top of the coarse, cobble beach ridge, where scattered shrubs are typically dominant. The most commonly occurring

species include ninebark (*Physocarpus opulifolius*), mountain alder (*Alnus crispa*), mountain ash (*Sorbus decora*), and marsh pea (*Lathyrus palustris*). Additional common herbaceous species include blue wild-rye (*Elymus glaucus*), evening primrose (*Oenothera biennis*), bunchberry (*Cornus canadensis*), bluejoint grass (*Calamagrostis canadensis*), grass-leaved goldenrod (*Euthamia graminifolia*), and scouring rush (*Equisetum hyemale*). Additional common shrubs include wild red raspberry (*Rubus strigosus*), wild rose (*Rosa acicularis*), red-osier dogwood (*Cornus stolonifera*), bush honeysuckle (*Diervilla lonicera*), soapberry (*Shepherdia canadensis*), and northern gooseberry (*Ribes oxycanthoides*). Scattered trees are typically located along the inland edges of the community and include mountain ash, white spruce (*Picea glauca*), northern white-cedar (*Thuja occidentalis*), balsam fir (*Abies balsamea*), quaking aspen (*Populus tremuloides*), and paper birch (*Betula papyrifera*).

Noteworthy Animals

The high-energy environment of the cobble shore appears to provide little stable habitat for terrestrial insects, but the sediments and rock surfaces are sometimes rich in aquatic invertebrates.

Rare Plants

Carex atratiformis (sedge, state threatened)

Polygonum viviparum (alpine bistort, state threatened)

Trisetum spicatum (downy oat-grass, state special concern)

Rare Animals

None documented.

Biodiversity Management Considerations

Off-road vehicles (ORVs) are commonly used to travel across volcanic cobble shores, destroying vegetation and further reducing diversity. Eliminating illegal ORV activity is a primary means of protecting volcanic cobble shores. Maintaining a forested buffer will help prevent soil erosion and runoff into the community and may help reduce the local seed source of non-native invasive plants. Like other natural communities, monitoring and control efforts to detect and remove invasive plants will help protect the ecological integrity of volcanic cobble shore. Several invasive species that may have potential to colonize the community include reed (*Phragmites australis*), glossy buckthorn (*Rhamnus frangula*), and multiflora rose (*Rosa multiflora*).

Variation

Community structure and species composition are influenced by the size and type of pebbles or cobbles, steepness of shoreline slope, and presence or absence of terracing, groundwater seepage, and streams.

Similar Natural Communities

Limestone cobble shore, sandstone cobble shore, volcanic bedrock lakeshore, volcanic bedrock glade, and sand and gravel beach.

Relevant Literature

Albert, D.A., P. Comer, D. Cuthrell, D. Hyde, W. MacKinnon, M. Penskar, and M. Rabe. 1997. The Great Lakes bedrock lakeshores of Michigan. Michigan Natural Features Inventory, Lansing, MI. 218 pp.

Bornhorst, T.J., and W.I. Rose. 1994. Self-guided geological field trip to the Keweenaw Peninsula, Michigan. Proceedings of the Institute on Lake Superior Geology. Volume 40, Part 2. 185 pp.

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BEDROCK LAKESHORE COMMUNITIES

Limestone Bedrock Lakeshore

Global/State Rank: G3/S2

Overview

Limestone bedrock lakeshore is a sparsely vegetated natural community dominated by lichens, mosses, and herbaceous vegetation. This community, which is also referred to as alvar pavement and limestone pavement lakeshore, occurs along the shorelines of northern Lake Michigan and Lake Huron on broad, flat, horizontally bedded expanses of limestone or dolomite bedrock. On the Lake Michigan shoreline, limestone bedrock lakeshore is concentrated along the Garden Peninsula and the southern part of Schoolcraft County. Along Lake Huron, it is located east of the Les Cheneaux Islands, on Drummond Island, and on Thunder Bay Island.

Landscape Context

The bedrock includes both limestone and dolomite (or dolostone) of marine origin. Limestone bedrock lakeshores of Michigan occur where flat bedrock of the Niagaran Escarpment is exposed. Bedrock is of Middle and Late Ordovician and Early Silurian origin (405 to 500 million years ago), when shallow, inland seas covered the Lake Michigan Basin. Shoreline bedrock of Thunder Bay Island dates to the more recent Devonian period (345 to 405 million years ago). A veneer of locally derived limestone cobbles of varying thickness occurs along large stretches of limestone bedrock shorelines. Along the inland margins of the limestone pavement, there is often a low ridge of limestone cobble deposited by ice scour and major storm events.

Along the shoreline the community may be interspersed with areas of limestone cobble shore and sand and gravel beach. Other associated shoreline communities in areas of limestone bedrock lakeshore include coastal fen and Great Lakes marsh. Along the inland margin, limestone bedrock lakeshore is typically bordered by boreal forest or mesic northern forest and less commonly by limestone bedrock glade, alvar, or rich conifer swamp.

Soils

Almost no soil development takes place directly on the limestone pavement, where storm waves and ice routinely scour the rock surface. Consequently, plant establishment is generally limited to cracks, joints, and depressions in the bedrock, where small amounts of organic matter, cobble, and finer sediments accumulate. Because it is formed from marine organisms, limestone bedrock is rich in calcium carbonates, resulting in a mildly alkaline soil pH. Resistance of the bedrock to erosion is variable. Both limestone and dolostone are readily dissolved by rainwater, producing solution depressions and cracks that often connect to the underlying groundwater system. However, limestone rich in mineral soil particles originating from terrestrial sources is resistant to solution and typically contains few cracks.

Natural Processes

Storms, wind, winter ice scour, fluctuating water levels, and severe desiccation produce a stressful, unstable environment for vegetation establishment and growth. During storms, flooding, pounding waves, and high winds rearrange large boulders, smaller rocks, and fine sediments, eliminating local pockets of vegetation and creating new habitat patches for plant establishment. Winter ice scour scrapes clean smooth areas of bedrock and deposits fresh loads of boulders,

cobble, and sediments as the ice and snow melt. Thin soils, full exposure, and high winds combine to produce severely desiccating conditions, especially during summer dry periods. Changes in Great Lakes water levels result in vegetation colonizing recently exposed shorelines during periods of low water only to be submerged and often eliminated during periods of high water. Windthrow is common along the upland margin, where trees are able to mature but are shallowly rooted in the thin soils overlying the bedrock.

Vegetation

Limestone bedrock lakeshore is a sparsely vegetated community supporting a flora tolerant of mildly alkaline conditions and frequent disturbance. The community is dominated by herbaceous plants, mosses, and lichens, with tree cover generally limited to the inland edge. Characteristic herbaceous plants, in order of number of occurrences observed during surveys of the community, include low calamint (*Calamintha arkansana*), hair grass (*Deschampsia cespitosa*), Baltic rush (*Juncus balticus*), silverweed (*Potentilla anserina*), harebell (*Campanula rotundifolia*), smooth aster (*Aster laevis*), common water horehound (*Lycopus americanus*), northern bog violet (*Viola nephrophylla*), grass-leaved goldenrod (*Euthamia graminifolia*), and Kalm's St. John's-wort (*Hypericum kalmianum*). Other characteristic plants include panic grass (*Panicum lindheimeri*), hair grass (*D. flexuosa*), balsam ragwort (*Senecio pauperculus*), Ohio goldenrod (*Solidago ohioensis*), golden-seeded spike-rush (*Eleocharis elliptica*), dwarf Canadian primrose (*Primula mistassinica*), sedges (*Carex viridula* and *C. eburnea*), and white camas (*Zigadenus glaucus*). The following trees and shrubs are commonly observed: northern white-cedar (*Thuja occidentalis*), paper birch (*Betula papyrifera*), white spruce (*Picea glauca*), balsam poplar (*Populus balsamifera*), shrubby cinquefoil (*Potentilla fruticosa*), soapberry (*Shepherdia canadensis*), common juniper (*Juniperus communis*), and bearberry (*Arctostaphylos uva-ursi*).

Limestone bedrock lakeshores are characterized by a zonal gradation of plant communities, changing in response to distance from the lake. The width of the zones varies with Great Lakes water level fluctuations. Wave action and ice scour have their greatest impact closest to the lake. The "splash/scrape zone," which averages 9 m (30 ft) in width, is very sparsely vegetated. Typical plant species include Baltic rush, silverweed, and balsam poplar. These species get established in cracks where there is some protection from severe ice scour and storm events. Throughout this zone, small pools of standing water are common on the bedrock. Inland from the splash/scrape zone, vegetation density increases as soil accumulates in and around cracks. The "vegetated zone," which averages 25 m (75 ft) in width, is characterized by patchy establishment of vegetation interspersed with areas of exposed bedrock. Common species include low calamint, shrubby cinquefoil, panic grass, and hair grass, as well as the previously mentioned species from the splash/scrape zone. Farther inland, sand accumulations or "cobble ridges" on the bedrock surface afford a suitable substrate for the establishment of woody plants and denser assemblages of herbaceous plants. Cobble ridges are dominated by scattered shrubs and stunted trees including northern white-cedar, white spruce, and balsam poplar.

Noteworthy Animals

Limestone bedrock lakeshore provides stopover and feeding corridors for migratory songbirds, including many warbler species.

Rare Plants

Carex richardsonii (Richardson's sedge, state special concern)

Carex scirpoidea (bulrush sedge, state threatened)

Cirsium hillii (Hill's thistle, state special concern)

Eleocharis compressa (flattened spike-rush, state threatened)

Iris lacustris (dwarf lake iris, federal/state threatened)

Pinguicula vulgaris (butterwort, state special concern)
Piperia unalascensis (Alaska orchid, state special concern)
Solidago houghtonii (Houghton's goldenrod, federal/state threatened)

Rare Animals

Catinella exile (Pleistocene catinella, state threatened)
Flexamia delongi (leafhopper, state special concern)
Lanius ludovicianus migrans (loggerhead shrike, state endangered)
Vertigo bollesiana (delicate vertigo, state threatened)
Vertigo elatior (tapered vertigo, state special concern)
Vertigo hubrichti (Hubricht's vertigo, endangered)
Vertigo morsei (six-whorl vertigo, endangered)
Vertigo nylanderii (deep-throat vertigo, endangered)

Biodiversity Management Considerations

Trampling of vegetation and off-road vehicle traffic use can kill or reduce vegetation coverage, destroying the root systems that bind small accumulations of soil to cracks in the bedrock. The removal of lakeshore vegetation facilitates the loss of soil by wind, rain, ice, or wave action, which is especially damaging in this erosive landscape where soil development and plant reestablishment are slow. Eliminating illegal off-road vehicle activity is a primary means of protecting the ecological integrity of limestone bedrock lakeshore and associated shoreline communities.

Invasive plant species that threaten the diversity and community structure of limestone bedrock lakeshore include spotted knapweed (*Centaurea maculosa*), mossy stonecrop (*Sedum acre*), ox-eye daisy (*Chrysanthemum leucanthemum*), common St. John's-wort (*Hypericum perforatum*), Canada bluegrass (*Poa compressa*), Kentucky bluegrass (*P. pratensis*), hawkweeds (*Hieracium* spp.), sheep sorrel (*Rumex acetosella*), garden tansy (*Tanacetum vulgare*), common mullein (*Verbascum thapsus*), and glossy buckthorn (*Rhamnus frangula*). In addition, empty shells of zebra mussels (*Dreissena polymorpha*), a small invasive bivalve mussel, form deep piles on limestone bedrock pavement and locally limit vegetation establishment and impact soil accumulation, deposition, and erosion. Maintaining a mature, unfragmented forested buffer around limestone bedrock lakeshores may help limit the local seed source for invasive species distributed by wind or birds. Monitoring and control efforts to detect and remove these and other invasive species will help maintain the native biodiversity of limestone bedrock lakeshore and surrounding natural communities.

Variation

The composition of the limestone bedrock lakeshore is quite variable and may include areas of sand, silt, or clay minerals, which alter the rock's resistance to erosion, influence the formation of crevices, and affect hydrologic conditions of the community.

Similar Natural Communities

Limestone cobble shore, limestone bedrock glade (alvar glade), alvar (alvar grassland), sandstone bedrock lakeshore, volcanic bedrock lakeshore, and granite bedrock lakeshore.

Relevant Literature

Albert, D.A., P. Comer, D. Cuthrell, D. Hyde, W. MacKinnon, M. Penskar, and M. Rabe. 1997. The Great Lakes bedrock lakeshores of Michigan. Michigan Natural Features Inventory, Lansing, MI. 218 pp.

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For a full list of references used to create this description, please refer to the natural community abstract for limestone bedrock lakeshore.

Sandstone Bedrock Lakeshore

Global/State Rank: G4G5/S2

Overview

Sandstone bedrock lakeshore is a sparsely vegetated community that occurs along the Lake Superior shoreline in the central and western Upper Peninsula. Exposed sandstone bedrock is prominent, with lichens and mosses locally dominant, and scattered sedges, grasses, forbs, shrubs, and occasionally trees restricted to cracks, joints, and depressions in the bedrock.

Landscape Context

Sandstone bedrock lakeshore occurs along the shores of Lake Superior as part of the Copper Harbor Conglomerate, Jacobsville Sandstone, and Nonesuch and Freda Formations, stretching from the Wisconsin-Michigan boundary in the west to east of Munising in Pictured Rocks National Lakeshore. The largest continuous stretch of sandstone bedrock lakeshore in Michigan occurs along Lake Superior within Porcupine Mountain Wilderness State Park, where much of the bedrock tilts northward toward the lake. Level areas of sandstone bedrock lakeshore occur along Keweenaw Bay on Point Abbaye in Baraga County.

Sandstone bedrock lakeshore is typically bordered along its inland margin by boreal forest, mesic northern forest, and occasionally by forested wetlands. Along the shoreline, sandstone bedrock lakeshore is interspersed with areas of sandstone lakeshore cliff, granite bedrock lakeshore, granite lakeshore cliff, volcanic bedrock lakeshore, volcanic cobble shore, and sand and gravel beach.

Soils

Almost no soil development occurs on the sandstone bedrock. Soil development and plant establishment are limited to cracks, joints, and depressions in the bedrock where small amounts of sand and organic matter accumulate. The breakdown of sandstone and plant matter results in an acidic, sandy, organic-rich soil. Soil depth is shallow due to wave, wind, and ice action.

Natural Processes

Storms, wind, winter ice scour, fluctuating water levels, and severe desiccation produce a stressful, unstable environment for vegetation establishment and growth. Changes in Great Lakes water levels result in vegetation colonizing recently exposed cracks, joints, and depressions in the bedrock during periods of low water. When water levels rise, the sparse vegetation is submerged or pounded, and scoured by waves and ice. Thin soils, full exposure, and high winds combine to produce severely desiccating conditions, especially during summer droughts. Frequent fog serves to mitigate drought stress. Windthrow is common along the inland margin, where trees are able to mature but are typically shallowly rooted.

Vegetation

Sandstone bedrock lakeshore is a sparsely vegetated community supporting a flora of lichens, mosses, herbaceous plants, shrubs, and dwarfed trees. Mature tree cover is generally limited to the inland edge. Most vegetation grows from cracks and joints in the bedrock. Small pools of water, which support wetland plants along their edges, collect in isolated depressions from storm waves or where small intermittent streams flow across the bedrock. Common herbaceous plants include hair grass (*Deschampsia cespitosa*), upland white goldenrod (*Solidago ptarmicoides*), Gillman's goldenrod (*S. simplex*), grass-leaved goldenrod (*Euthamia graminifolia*), harebell

(*Campanula rotundifolia*), Kalm's lobelia (*Lobelia kalmii*), balsam ragwort (*Senecio pauperculus*), wild strawberry (*Fragaria virginiana*), jewelweed (*Impatiens capensis*), northern bugleweed (*Lycopus uniflorus*), sedge (*Carex viridula*), fireweed (*Epilobium angustifolium*), and rushes (*Juncus* spp.). Common shrubs, mostly occurring in a dwarfed condition, include ninebark (*Physocarpus opulifolius*), wild rose (*Rosa acicularis*), serviceberries (*Amelanchier* spp.), thimbleberry (*Rubus parviflorus*), mountain alder (*Alnus crispa*), pussy willow (*Salix discolor*), and Bebb's willow (*S. bebbiana*). Common trees, mostly occurring as small seedlings and saplings, include northern white-cedar (*Thuja occidentalis*), balsam poplar (*Populus balsamifera*), quaking aspen (*P. tremuloides*), red maple (*Acer rubrum*), paper birch (*Betula papyrifera*), and white ash (*Fraxinus americana*). Additional shrubs and trees growing along the inland margins include choke cherry (*Prunus virginiana*), bush honeysuckle (*Diervilla lonicera*), American fly honeysuckle (*Lonicera canadensis*), hemlock (*Tsuga canadensis*), white spruce (*Picea glauca*), balsam fir (*Abies balsamea*), yellow birch (*Betula alleghaniensis*), sugar maple (*A. saccharum*), and quaking aspen.

Invasive species observed in sandstone bedrock lakeshore include reedtop (*Agrostis gigantea*), spotted knapweed (*Centaurea maculosa*), ox-eye daisy (*Chrysanthemum leucanthemum*), glaucous king devil (*Hieracium piloselloides*), common St. John's-wort (*Hypericum perforatum*), Canada bluegrass (*Poa compressa*), Kentucky bluegrass (*P. pratensis*), reed canary grass (*Phalaris arundinacea*), sheep sorrel (*Rumex acetosella*), garden tansy (*Tanacetum vulgare*), and common mullein (*Verbascum thapsus*).

Noteworthy Animals

The high-energy environment of sandstone bedrock lakeshore appears to provide little stable habitat for terrestrial insects, but the sediments, rock surfaces, and pools are likely important habitat for aquatic invertebrates.

Rare Plants

Carex atratiformis (sedge, state threatened)

Trisetum spicatum (downy oat-grass, state special concern)

Rare Animals

Falco columbarius (merlin, state threatened)

Falco peregrinus (peregrine falcon, state endangered)

Haliaeetus leucocephalus (bald eagle, state special concern)

Biodiversity Management Considerations

Excessive trampling or off-road vehicle use can kill lakeshore vegetation. The loss of vegetation can accelerate soil loss through wind, rain, or wave action. After soil has been lost, soil development and plant reestablishment are slow. Eliminating illegal off-road vehicle activity is a primary means of protecting the ecological integrity of sandstone bedrock lakeshore and associated shoreline communities. Invasive species that threaten the diversity and community structure of sandstone bedrock lakeshore include reedtop, spotted knapweed, ox-eye daisy, hawkweeds (*Hieracium* spp.), common St. John's-wort, Canada bluegrass, Kentucky bluegrass, reed canary grass, sheep sorrel, garden tansy, and common mullein. Maintaining a mature, unfragmented forested buffer around sandstone bedrock lakeshores may help limit the local seed source for invasive species distributed by wind or birds. Monitoring and control efforts to detect and remove these and other invasive species will help maintain the native biodiversity of sandstone bedrock lakeshore and surrounding natural communities.

Variation

The sandstone bedrock along Lake Superior varies significantly in texture and erosion resistance, which can influence soil development and plant species composition.

Similar Natural Communities

Sandstone lakeshore cliff, volcanic bedrock lakeshore, granite bedrock lakeshore, limestone bedrock lakeshore, volcanic bedrock glade, granite bedrock glade, and volcanic lakeshore cliff.

Relevant Literature

- Albert, D.A., P. Comer, D. Cuthrell, D. Hyde, W. MacKinnon, M. Penskar, and M. Rabe. 1997. The Great Lakes bedrock lakeshores of Michigan. Michigan Natural Features Inventory, Lansing, MI. 218 pp.
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Granite Bedrock Lakeshore

Global/State Rank: G4G5/S2

Overview

Granite bedrock lakeshore occurs along the Lake Superior shoreline as small knobs of sparsely vegetated granitic bedrock, typically between longer expanses of steep sandstone cliffs. Mosses and lichen dominate, with a few herbs, shrubs, and tree saplings and stunted trees restricted to areas above the strong influence of waves and ice scour. Granitic bedrock is restricted to scattered headlands (erosion-resistant knobs) along the Lake Superior shoreline between the city of Marquette and the Huron Mountain Club, about 48 km (30 miles) to the northwest. Granitic headlands include Sugarloaf Mountain (Wetmore Landing), Partridge Bay, Thoney Point, Saux Head Hill, and Granite Point. The Huron Islands, located just west of the Huron Mountains and about 10 km (6 miles) east of Point Abbaye, are the westernmost exposure of granitic bedrock along the southern shore of Lake Superior. Quartzite bedrock, which is included with the granitic rock types, is much less prevalent along the Lake Superior shoreline. A small outcrop of quartzite extends into Lake Superior approximately 3 km (2 miles) southeast of the city of Marquette, near Harvey.

Landscape Context

A broad range of igneous and metamorphic rock, including gneiss, schist, granite, and quartzite, are often loosely referred to as “granitic” or “granite.” The granitic rock along the Lake Superior shoreline near the city of Marquette is among the oldest rock in the state, with coastal bedrock exposures that are approximately 2.3 billion years old. Small exposed knobs of the older granitic bedrock are typically surrounded by long expanses of younger, more recently formed Jacobsville sandstone cliffs. Quartzite bedrock east of Marquette was developed from quartz-rich sandstone, when the sandstone was deeply buried and the resulting high temperatures fused the quartz grains together to form an extremely hard quartzite rock highly resistant to weathering.

Granite bedrock lakeshore occurs as relatively small exposures, from 0.4 to 2.1 km (0.25 to 1.25 miles) in length and typically about 30 m (120 feet) wide. The entire bedrock feature typically extends farther inland, and grades into granite bedrock glade farther from the lake. Adjacent natural communities include sandstone lakeshore cliff, granite bedrock glade, granite lakeshore cliff, sand and gravel beach, boreal forest, dry-mesic northern forest, and mesic northern forest.

Soils

Because the granitic rocks along the coast are highly polished and extremely resistant to weathering, very little soil development takes place. Storm waves and ice scour also regularly remove developing soils. Freshly broken rock surfaces are circumneutral to mildly alkaline in pH, but the surface of weathered bedrock is acid. Some organic soil development takes place in cracks, under low shrubs, or in pools. Vascular plants are typically limited to these shallow cracks, exfoliation depressions, and pool edges where moisture and available nutrients are concentrated.

Natural Processes

Strong winds, waves, and winter ice create a stressed, unstable environment. Lack of soil development, combined with exposure to strong winds off Lake Superior, result in water stress for vegetation, although frequent coastal fog helps ameliorate these desiccating effects. Lightning strikes result in occasional tree mortality and fires. Wind storms maintain the open forest

structure, causing blowdown of shallowly rooted trees. Fire and windthrow are both confined to the upland margin or “shrub zone” of granite bedrock lakeshore. Small pools occur where blocks of stone were plucked from the rock by glacial ice or loosened by freeze-thaw cycles and later removed by storm waves. Along Lake Superior, some larger rock pools remain flooded throughout the year and support vegetation only along their margins.

Vegetation

Many of the same herbs, shrubs, and trees found on granite bedrock glade and volcanic bedrock lakeshore also occur on granite bedrock lakeshore, but the arctic-subalpine species characteristic of the volcanic rock are typically absent. Common vascular species (80% or greater occurrence) of the open granitic lakeshore include ticklegrass (*Agrostis hyemalis*), harebell (*Campanula rotundifolia*), poverty grass (*Danthonia spicata*), hair grass (*Deschampsia cespitosa*), Canada bluegrass (*Poa compressa*), and low sweet blueberry (*Vaccinium angustifolium*). Other characteristic plants include paper birch (*Betula papyrifera*), three-toothed cinquefoil (*Potentilla tridentata*), yarrow (*Achillea millefolium*), grass-leaved goldenrod (*Euthamia graminifolia*), and fireweed (*Epilobium angustifolium*). Farther from the lakeshore, shrubs, tree saplings, and stunted trees become relatively common on rounded slopes and summits of granitic knobs. Typical shrubs include bearberry (*Arctostaphylos uva-ursi*), bush honeysuckle (*Diervilla lonicera*), common juniper (*Juniperus communis*), mountain ash (*Sorbus decora*), mountain alder (*Alnus crispa*), and ninebark (*Physocarpus opulifolius*). Common tree species are white pine (*Pinus strobus*), quaking aspen (*Populus tremuloides*), northern white-cedar (*Thuja occidentalis*), white spruce (*Picea glauca*), and jack pine (*Pinus banksiana*). Low moist cliffs and vertical faces of boulders are dominated by lichens and ferns including fragile fern (*Cystopteris fragilis*), rusty woodsia (*Woodsia ilvensis*), and common polypody (*Polypodium virginianum*). Pools in the rock commonly support several herbaceous plants along their edges, including bluejoint grass (*Calamagrostis canadensis*), hair grass, Kalm’s lobelia (*Lobelia kalmii*), and wool-grass (*Scirpus cyperinus*).

The plant community consists of distinct zones with different dominants. Wave action and ice scour close to the lakeshore produce a “wave-washed zone” that is almost devoid of vegetation except for small tufts of mosses and lichen. Above this high-energy zone is a spray zone or open, vegetated zone, where the dominant vegetation consists of mosses and lichens, with lichen cover increasing with elevation above the water. Herbs and shrubs are restricted to bedrock cracks in the lower part of this zone, but become more common with increasing elevation above the lake. Above the strong influence of storm waves and ice scour, woody vegetation becomes dominant. Small pools occur where blocks of stone were removed by winter ice and storm waves, or were plucked from the rock knobs by glacial ice.

Noteworthy Animals

The high-energy environment of granite bedrock lakeshore appears to provide little stable habitat for terrestrial insects, but the sediments, rock surfaces, and pools are likely important habitat for aquatic invertebrates.

Rare Plants

Trisetum spicatum (downy oat-grass, state special concern)

Rare Animals

Falco peregrinus (peregrine falcon, state endangered)

Haliaeetus leucocephalus (bald eagle, state special concern)

Biodiversity Management Considerations

Excessive trampling or off-road vehicle use can kill lakeshore vegetation. The loss of vegetation can accelerate soil loss through wind, rain, or wave action. After soil has been lost, soil development and plant reestablishment are slow. Invasive species that have the potential to reduce diversity and alter community structure of granite bedrock lakeshore include spotted knapweed (*Centaurea maculosa*), ox-eye daisy (*Chrysanthemum leucanthemum*), common St. John's-wort (*Hypericum perforatum*), Canada bluegrass (*Poa compressa*), Kentucky bluegrass (*P. pratensis*), hawkweeds (*Hieracium* spp.), sheep sorrel (*Rumex acetosella*), garden tansy (*Tanacetum vulgare*), and common mullein (*Verbascum thapsus*). Maintaining a mature, unfragmented forested buffer around granite bedrock lakeshores may help limit the local seed source for invasive species distributed by wind or birds. Monitoring and control efforts to detect and remove these and other invasive species will help maintain the native biodiversity of granite bedrock lakeshore and surrounding natural communities.

Variation

Because this plant community occurs on a broad range of igneous and metamorphic rocks, including gneiss, schist, granite, and quartzite, it may be possible to identify subtypes of this plant community.

Similar Natural Communities

Granite bedrock glade, volcanic bedrock lakeshore, volcanic lakeshore cliff, volcanic bedrock glade, sandstone bedrock lakeshore, sandstone lakeshore cliff, and limestone bedrock lakeshore.

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For a full list of references used to create this description, please refer to the natural community abstract for granite bedrock lakeshore.

Volcanic Bedrock Lakeshore

Global/State Rank: G4G5/S3

Overview

Volcanic bedrock lakeshore is a sparsely vegetated community dominated by mosses and lichens, with a scattered coverage of vascular plants. The community is located primarily along the Lake Superior shoreline on the Keweenaw Peninsula and Isle Royale. This Great Lakes coastal community includes all types of volcanic bedrock, including basalt, conglomerate composed of volcanic rock, and rhyolite.

Landscape Context

Bedrock of the Keweenaw Peninsula and Isle Royale was deposited from 1,100 to 1,000 million years ago, during the Late Precambrian, a period of extensive surface volcanic activity. Rather than forming volcanic cones, the basaltic lavas flowed out through long fissures, covering the landscape with thick deposits of lava, called flood basalt. The huge mass of Keweenaw rock, up to 25 km (15.5 miles) thick, eventually sagged to form a structural basin, now occupied by Lake Superior. The sagging caused the volcanic rock of the Keweenaw Peninsula to tilt steeply downward to the north, toward the center of the Lake Superior basin, while the volcanic rock of Isle Royale's south shoreline tilted steeply south, also facing the center of Lake Superior. In contrast, the south shore of the Keweenaw Peninsula and the north shore of Isle Royale form steep cliffs. Volcanic rhyolite, an angular, reddish rock found locally on the south shore of the Keweenaw Peninsula east of Bete Grise, has a depauperate flora similar to that of massive basalt. This community also occurs along the Lake Superior shoreline in Ontario and Minnesota.

Volcanic bedrock lakeshore is typically bordered by boreal forest along its upland margin and occasionally by dry-mesic northern forest, mesic northern forest, or volcanic bedrock glade. Where streams flow through the community, occasionally northern shrub thicket may border its inland edge. Along the shoreline, the volcanic bedrock lakeshore is interspersed with areas of volcanic lakeshore cliff, volcanic cobble shore, and sand and gravel beach.

Soils

Almost no soil development takes place on either the massive, fine-grained basalts or the volcanic conglomerates. The only places where plants are able to establish are in cracks, joints, vesicles, and depressions in the bedrock, where small amounts of organic matter accumulate. Cracks, joints, and depressions are much more abundant on the volcanic conglomerate, but still provide relatively few places for soil development. Freshly broken rock surfaces are mildly alkaline in pH.

Natural Processes

Extreme conditions characterize all parts of this plant community. Near the water's edge, storm waves regularly scour the rock. During the winter, ice scours and abrades the rock even more violently. Freezing rain and mist coat both the rock and vegetation, and in combination with high winds, result in dwarf shrubs and stunted trees along the shore. Fog occurs on an almost daily basis, allowing plants more characteristic of cooler northern or high elevation habitats to survive beyond their normal range. Along the upland margin of volcanic bedrock lakeshore, lightning strikes result in occasional tree mortality and fires and wind storms cause blowdown of shallowly rooted trees. Fire and windthrow interact to maintain the open forest structure of the upland margin of volcanic bedrock lakeshore.

Vegetation

The plants covering the greatest percentage of the lakeshores are mosses and lichens, with only scattered coverage of vascular plants. Mosses and lichens are able to establish and survive close to the lake, while vascular plants are generally above the zone of active storm waves and ice scour. Herbaceous species, listed in order of common occurrence, include harebell (*Campanula rotundifolia*), wild strawberry (*Fragaria virginiana*), three-toothed cinquefoil (*Potentilla tridentata*), downy oat-grass (*Trisetum spicatum*, state special concern), yarrow (*Achillea millefolium*), hair grass (*Deschampsia cespitosa*), butterwort (*Pinguicula vulgaris*, state special concern), tufted bulrush (*Trichophorum cespitosum*), fescue (*Festuca saximontana*), dwarf Canadian primrose (*Primula mistassinica*), and the invasive plant Canada bluegrass (*Poa compressa*). Other common species include balsam ragwort (*Senecio pauperculus*), grass-leaved goldenrod (*Euthamia graminifolia*), Gillman's goldenrod (*Solidago simplex*), fireweed (*Epilobium angustifolium*), northern bog violet (*Viola nephrophylla*), poverty grass (*Danthonia spicata*), and wormwood (*Artemisia campestris*). Prevalent shrubs include low sweet blueberry (*Vaccinium angustifolium*), Alpine blueberry (*V. uliginosum*, state threatened), bearberry (*Arctostaphylos uva-ursi*), common juniper (*Juniperus communis*), creeping juniper (*J. horizontalis*), dwarf raspberry (*Rubus pubescens*), ninebark (*Physocarpus opulifolius*), serviceberries (*Amelanchier* spp.), soapberry (*Shepherdia canadensis*), and bush honeysuckle (*Diervilla lonicera*). Stunted, shrub-sized trees included balsam fir (*Abies balsamea*), northern white-cedar (*Thuja occidentalis*), quaking aspen (*Populus tremuloides*), white pine (*Pinus strobus*), and white spruce (*Picea glauca*). Perched meadows at the edges of seasonal rock pools are dominated by bluejoint grass (*Calamagrostis canadensis*), hair grass, downy oat-grass, poverty grass, tufted bulrush, and sedges (*Carex buxbaumii* and *C. castanea*).

Several vegetation zones are often apparent. Wave action and ice scour are strongest near the lakeshore, producing a "wave-washed zone," that is almost devoid of vegetation except for scattered tufts of mosses and lichen. With greater distance above the lake, plant cover increases, with lichens predominating. On the high, dry rocks, a diversity of lichens forms a nearly continuous cover, while mosses, liverworts, herbs, and woody plants are also well represented. Herbs and woody plants are largely restricted to narrow cracks and joints in the rock, where there is limited soil development and greater moisture retention. Narrow, perched meadows of tufted grasses and sedges are found along the edges of seasonal rock pools.

Noteworthy Animals

Surveys of volcanic bedrock lakeshore documented twenty species of land snails, including two rare species with relict periglacial and arctic affinities, *Vertigo cristata* and *Vertigo paradoxa*.

Two groups of rare species are represented on the volcanic bedrock lakeshore, arctic-alpine species characteristic of more northerly open environments and disjunct species from the mountains of the west and Pacific Northwest. Cool, moist, and foggy conditions prevail along the shores of Lake Superior's Keweenaw Peninsula and Isle Royale, accounting for the affinity of the plant communities of the shoreline to those of more northern latitudes. The rocky coastal habitat along Lake Superior also shares bedrock conditions with the Pacific Northwest.

Rare Plants

Allium schoenoprasum var. *sibiricum* (wild chives, state threatened)
Antennaria rosea (rosy pussytoes, presumed extirpated from Michigan)
Arnica lonchophylla (longleaf arnica, state endangered)
Braya humilis (low northern rock cress, state threatened)

Calamagrostis lacustris (northern reedgrass, state threatened)
Calamagrostis stricta (narrow-leaved reedgrass, state threatened)
Calypso bulbosa (calypso, state threatened)
Carex media (sedge, state threatened)
Carex rossii (Ross's sedge, state threatened)
Carex scirpoides (bulrush sedge, state threatened)
Castilleja septentrionalis (pale Indian paintbrush, state threatened)
Crataegus douglasii (Douglas's hawthorn, state special concern)
Cryptogramma acrostichoides (American rock-brake, state threatened)
Cypripedium arietinum (ram's head lady's-slipper, state special concern)
Danthonia intermedia (wild oatgrass, state special concern)
Draba arabisans (rock whitlow-grass, state special concern)
Elymus glaucus (blue wild-rye, state special concern)
Empetrum nigrum (black crowberry, state threatened)
Luzula parviflora (small-flowered wood rush, state threatened)
Phacelia franklinii (Franklin's phacelia, state threatened)
Phleum alpinum (mountain timothy, presumed extirpated from Michigan)
Pinguicula vulgaris (butterwort, state special concern)
Poa alpina (alpine bluegrass, state threatened)
Polygonum viviparum (alpine bistort, state threatened)
Potentilla pensylvanica (prairie cinquefoil, state threatened)
Sagina nodosa (pearlwort, state threatened)
Senecio indecorus (rayless mountain ragwort, state threatened)
Trisetum spicatum (downy oat-grass, state special concern)
Vaccinium cespitosum (dwarf bilberry, state threatened)
Vaccinium uliginosum (Alpine blueberry, state threatened)
Viburnum edule (squashberry, state threatened)

Rare Animals

Falco peregrinus (Peregrine falcon, state endangered)
Haliaeetus leucocephalus (bald eagle, state special concern)
Vertigo cristata (land snail, state special concern)
Vertigo paradoxa (land snail, state special concern)

Biodiversity Management Considerations

Lichens and mosses are especially sensitive to off-road vehicle and foot traffic. In many stretches of the shoreline this damage is minimal because of the extreme steepness of the shores. While herbaceous vegetation is also vulnerable to foot traffic, roots are often protected within cracks in the rock. Soil recovery and plant reestablishment are slow in this harsh environment. Invasive species that threaten the diversity and community structure of volcanic bedrock lakeshore include spotted knapweed (*Centaurea maculosa*), ox-eye daisy (*Chrysanthemum leucanthemum*), Canada bluegrass, Kentucky bluegrass (*P. pratensis*), hawkweeds (*Hieracium* spp.), common St. John's-wort (*Hypericum perforatum*), sheep sorrel (*Rumex acetosella*), garden tansy (*Tanacetum vulgare*), and common mullein (*Verbascum thapsus*). Maintaining a mature, unfragmented forested buffer around volcanic bedrock lakeshores may help limit the local seed source for invasive species distributed by wind or birds. Monitoring and control efforts to detect and remove these and other invasive species will help maintain the ecological integrity of volcanic bedrock lakeshore and surrounding natural communities.

Variation

In earlier versions of the community classification, the volcanic conglomerates had been considered a separate vegetation type due to the higher plant species richness and greater vegetative cover on the conglomerates of the Keweenaw Peninsula. However, because the basaltic bedrock of Manitou Island at the east end of the Keweenaw Peninsula and on Isle Royale supports a similar and equally diverse vascular flora as the conglomerate of the Keweenaw Peninsula, all of the volcanic bedrock lakeshore types have been combined into one type, volcanic bedrock lakeshore.

The basalt bedrock lakeshores of the Keweenaw Peninsula are characterized by lower plant richness and cover than the basalt bedrock lakeshores of Isle Royale, probably due to the lack of plant habitat in the form of cracks and small cavities in the smooth, fine-grained basaltic rock. In contrast, the volcanic conglomerates of the Keweenaw Peninsula support many more plant species and higher coverage values than the basalt. Rhyolite bedrock is also low in plant diversity and coverage compared to volcanic conglomerate bedrock.

Similar Natural Communities

Granite bedrock lakeshore, sandstone bedrock lakeshore, limestone bedrock lakeshore, volcanic cobble shore, volcanic bedrock glade, volcanic lakeshore cliff, and granite bedrock glade.

Relevant Literature

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For a full list of references used to create this description, please refer to the natural community abstract for volcanic bedrock lakeshore.

LAKESHORE CLIFF COMMUNITIES

Limestone Lakeshore Cliff

Global/State Rank: G4G5/S2

Overview

Limestone lakeshore cliff consists of vertical or near-vertical exposures of bedrock, which typically support less than 25% vascular plant coverage, although some rock surfaces can be densely covered with lichens, mosses, and liverworts. The community occurs in the Upper Peninsula along the shorelines of Lake Michigan and Lake Huron. Like all of Michigan's lakeshore cliffs, vegetation cover is sparse but abundant cracks and crevices combined with calcareous conditions result in greater plant diversity and coverage than on most other cliff types. Limestone lakeshore cliffs are characterized by high site moisture due to the proximity to the Great Lakes and a stressed and unstable environment because of severe waves, wind, and winter ice.

Landscape Context

Limestone and dolomite cliffs are scattered along the Niagaran Escarpment, from the Garden Peninsula on northwestern Lake Michigan to Mackinac and Drummond Islands in northern Lake Huron. Limestone cliffs extend farther west in Lake Michigan to the Door Peninsula of Wisconsin and farther east to the Bruce Peninsula of northern Lake Huron and Georgian Bay and on into northern Lake Ontario. In Michigan, limestone lakeshore cliff is typically bordered along its inland margin by boreal forest, mesic northern forest, or occasionally dry-mesic northern forest. Along the lakeshore, the community may border limestone bedrock lakeshore, limestone cobble shore, and sand and gravel beach.

Soils

Soil development is primarily limited to thin organic soils that form from decaying roots and other plant materials along the top of the cliff escarpment and ledges, in cracks and crevices in the bedrock, and at the base of the cliff. Breakdown of limestone and plant debris results in a sandy to loamy, organic-rich soil, with mildly alkaline pH.

Natural Processes

The vertical structure of cliffs causes constant erosion and restricts soil development to the cliff edge, cracks, ledges, and the base of the cliff where organic matter and soil particles can accumulate. The thin soils and direct exposure to wind, ice, and sun produce desiccating conditions that limit plant growth. However, cliff aspect and local seepages result in a variability of site moisture conditions. North- and east-facing cliffs are typically moister than south- and west-facing cliffs because of reduced wind and reduced direct exposure to the sun. Moisture can be locally present on cliff faces due to local groundwater seepage along the cliff face or surface flow across the cliff face during rain events or snow melt. Weathering results in the gradual exfoliation of exposed limestone along the cliff face, which adds to the instability of the ecosystem, reducing dependable habitat for plant establishment. As portions of the bedrock slough off, they form talus slopes of boulders and slabs along the base of cliffs and expose fresh, bare rock substrates along the cliff face. Windthrow of canopy trees along the cliff escarpment is

common due to the thin soils, unstable substrate, and high wind activity. Windblown trees along ledges and at the base of the cliff provide localized areas for soil accumulation.

Vegetation

While lichens, mosses, and liverworts are common on the exposed cliff face, vascular plant cover is sparse, being generally restricted to the flat, exposed bedrock at the upper edge of the cliff (i.e., lip), cracks, joints, and ledges in the cliff face, and along the cliff base if a ledge of talus, cobble, sand, or bedrock is present between the cliff and the open water. Lichens, mosses, and liverworts are especially abundant on moist seepages and cooler north aspects. The forested ridge tops support species such as red oak (*Quercus rubra*), sugar maple (*Acer saccharum*), northern white-cedar (*Thuja occidentalis*), balsam fir (*Abies balsamea*), and paper birch (*Betula papyrifera*). Common herbaceous plants occurring at the cliff edge and in the cliff-top forests include common polypody (*Polypodium virginianum*), large-leaved aster (*Aster macrophyllus*), wild strawberry (*Fragaria virginiana*), Canada mayflower (*Maianthemum canadense*), and wild sarsaparilla (*Aralia nudicaulis*). On the open cliff face the vegetation cover is sparse. Common tree species on the cliff face are northern white-cedar and paper birch, both species that root in crevices in the rock. Small, misshapen northern white-cedars over 1,000 years old have been found growing on the cliff faces near Fayette State Park. Balsam fir is often present in the subcanopy and understory. Ferns are prevalent along the cliff face, especially along moist exposures. Characteristic ferns include common polypody, fragile fern (*Cystopteris fragilis*), smooth cliff brake (*Pellaea glabella*), maidenhair spleenwort (*Asplenium trichomanes*), bracken fern (*Pteridium aquilinum*), Oregon woodsia (*Woodsia oregana*), and wall-rue (*Asplenium ruta-muraria*, state endangered). Common herbs on the cliff face include grass-leaved goldenrod (*Euthamia graminifolia*), herb Robert (*Geranium robertianum*), wild columbine (*Aquilegia canadensis*), yarrow (*Achillea millefolium*), and rock whitlow-grass (*Draba arabisans*, state special concern). Scattered and often stunted shrubs on the cliffs include soapberry (*Shepherdia canadensis*), bush honeysuckle (*Diervilla lonicera*), thimbleberry (*Rubus parviflorus*), mountain maple (*Acer spicatum*), choke cherry (*Prunus virginiana*), and red elderberry (*Sambucus racemosa*). These shrubs are also found scattered on talus at the base of the cliff. Several invasive plants commonly establish on the open cliffs, including common mullein (*Verbascum thapsus*), hound's-tongue (*Cynoglossum officinale*), bittersweet nightshade (*Solanum dulcamara*), and ox-eye daisy (*Chrysanthemum leucanthemum*). Recently, cryptoendolithic species of algae have been found to grow within the structure of the rock, creating the dark surface color of limestone rock.

Studies of limestone cliffs in Ontario found that there were three distinct zones of vegetation that share few species: ridge-top forest, cliff face, and talus. This zonation is also apparent in many Michigan limestone cliff systems; however, where the vertical height of the cliffs is low, there is a significant overlap in terms of species composition among the zones.

Noteworthy Animals

Large crevices in cliffs provide hibernacula for bats (*Myotis* spp.) and snakes, including eastern garter snake (*Thamnophis s. sirtalis*), western fox snake (*Elaphe vulpna*), and northern ring-necked snake (*Diadophis punctatus edwardsii*). Birds found commonly nesting on limestone and dolomite cliffs include American goldfinch (*Carduelis tristis*), Nashville warbler (*Vermivora ruficapilla*), and cliff swallow (*Petrochelidon pyrrhonota*). White-footed mouse (*Peromyscus leucopus*), deer mouse (*P. maniculatus*), and raccoon (*Procyon lotor*) also frequently utilize the cliffs. Eastern chipmunks (*Tamias striatus*) and other rodents burrow and nest in the protected habitat of the talus. Caddisflies (*Trichoptera*), mosquitoes (*Culicidae*), and solitary midges (*Thaumaleidae*) are found associated with continuous seepage areas on cliffs, and many species of spider (*Arachnida*) are common as well.

Rare Plants

Asplenium rhizophyllum (walking fern, state threatened)
Asplenium ruta-muraria (wall-rue, state endangered)
Asplenium scolopendrium var. *americanum* (Hart's-tongue fern, state endangered)
Asplenium trichomanes-ramosum (green spleenwort, state special concern)
Astragalus neglectus (Cooper's milk vetch, state special concern)
Braya humilis (low northern rock cress, state threatened)
Draba arabisans (rock whitlow-grass, state special concern)
Draba cana (ashy whitlow-grass, state threatened)
Dryopteris filix-mas (male fern, state special concern)
Pellaea atropurpurea (purple cliff-brake, state special concern)
Woodsia alpina (northern woodsia, state endangered)

Rare Animals

Falco columbarius (merlin, state threatened)
Falco peregrinus (Peregrine falcon, state endangered)
Gastrocopta holzingeri (lambda snaggletooth, endangered)
Haliaeetus leucocephalus (bald eagle, state special concern)
Vertigo bollesiana (delicate vertigo, state threatened)
Vertigo cristata (land snail, state special concern)
Vertigo paradoxa (land snail, state special concern)

Biodiversity Management Considerations

Threats to lakeshore cliffs include shoreline development, logging of adjacent uplands and associated soil erosion, excessive foot traffic along the upper edge, rock climbing, and invasive plants. The thin soils and unstable cliff environment make soil development and plant reestablishment slow, highlighting the importance of minimizing logging and excessive trampling along the upper edge of cliffs. Rock climbing can result in damage and loss of vegetation on the cliff face as many lichens and mosses of the cliffs have extremely slow recovery rates. Maintaining a mature, unfragmented forested buffer around limestone lakeshore cliffs may help limit the local seed source for invasive species distributed by wind or birds. Some of the invasive plants that may threaten the diversity and structure of limestone lakeshore cliffs include spotted knapweed (*Centaurea maculosa*), ox-eye daisy, Canada bluegrass (*Poa compressa*), Kentucky bluegrass (*P. pratensis*), sheep sorrel (*Rumex acetosella*), hawkweeds (*Hieracium* spp.), common mullein, hound's-tongue, and bittersweet nightshade. Monitoring and control efforts to detect and remove these and other invasive species will help maintain the ecological integrity of limestone lakeshore cliff and surrounding natural communities.

Variation

The limestone is quite variable across the Niagaran Escarpment, including magnesium-rich limestone (i.e., dolomite) and argillaceous or muddy limestone. These chemical differences result in different physical appearance and characteristics, such as hardness and amount and size of crevices. These physical and chemical differences translate to different habitat characteristics and species composition.

Similar Natural Communities

Limestone cliff, sandstone lakeshore cliff, volcanic lakeshore cliff, granite lakeshore cliff, granite cliff, sandstone cliff, limestone bedrock glade, limestone bedrock lakeshore, and volcanic cliff.

Relevant Literature

- Albert, D.A., P. Comer, D. Cuthrell, D. Hyde, W. MacKinnon, M. Penskar, and M. Rabe. 1997. The Great Lakes bedrock lakeshores of Michigan. Michigan Natural Features Inventory, Lansing, MI. 218 pp.
- Dorr, J.A., Jr., and D.F. Eschman. 1970. Geology of Michigan. University of Michigan Press, Ann Arbor, MI. 470 pp.
- Faber-Langendoen, D., ed. 2001. Plant communities of the Midwest: Classification in an ecological context. Association for Biodiversity Information, Arlington, VA. 61 pp. + appendix (705 pp.).
- Lawson, D.W., U. Matthes-Sears, and P.E. Kelly. 1999. The cliff ecosystems of the Niagara Escarpment. Pp. 362-374 in Savannas, barrens, and rock outcrop plant communities of North America, ed. R.C. Anderson, J.S. Fralish, and J.M. Baskin. Cambridge University Press, Cambridge, UK. 480 pp.
- Reschke, C., R. Reid, J. Jones, T. Feeney, and H. Potter. 1999. Conserving Great Lakes alvar: Final technical report of the International Alvar Conservation Initiative. The Nature Conservancy, Chicago, IL. 241 pp.
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Sandstone Lakeshore Cliff

Global/State Rank: G3/S2

Overview

Sandstone lakeshore cliff consists of vertical or near-vertical exposures of sandstone bedrock with sparse coverage of vascular plants, lichens, mosses, and liverworts. The community occurs primarily in the central and western Upper Peninsula along Lake Superior but also is found along a short stretch of shore along Lake Huron in the thumb region. Sandstone lakeshore cliffs range from 2 to 65 m (6 to 200 ft) high and are characterized by high site moisture due to the proximity to the Great Lakes and a stressed and unstable environment because of severe waves, wind, and winter ice.

Landscape Context

Sandstone cliffs occur primarily along the shores of Lake Superior as part of the Copper Harbor Conglomerate, Jacobsville Sandstone, and Nonesuch and Freda Formations, stretching from the Wisconsin-Michigan boundary in the west to east of Munising in Pictured Rocks National Lakeshore. There are over 24 km (15 miles) of cliff in the Porcupine Mountains, 10 km (6 miles) near Point Abbaye, 11 km (7 miles) in the Huron Mountain Club, and over 29 km (18 miles) at the Pictured Rocks National Lakeshore and Grand Island. In all, about 128 km (80 miles) of sandstone lakeshore cliff occur along Lake Superior, and another 0.5 miles of cliff composed of Marshall Sandstone occurs at Pointe Aux Barques on southern Lake Huron. Cliffs range from 2 to 65 m (6 to 200 ft) high, with the highest cliffs at the Pictured Rocks National Lakeshore. Similar sandstone cliffs occur along the Wisconsin shoreline of Lake Superior. In Michigan, sandstone lakeshore cliff is typically bordered along its inland margin by boreal forest, dry-mesic northern forest, mesic northern forest, and occasionally by forested wetlands. Along the shoreline, sandstone lakeshore cliffs are interspersed with areas of sandstone bedrock lakeshore, sandstone cobble shore, volcanic lakeshore cliff, volcanic bedrock lakeshore, volcanic cobble shore, granite bedrock lakeshore, granite lakeshore cliff, and sand and gravel beach.

Soils

There is almost no soil development on the cliffs except for shallow organic soil development along the narrow cliff summit and ledges, in crevices in the cliff face, and at the base of the cliff where sand particles, decaying roots, and plant debris accumulate. The breakdown of sandstone and plant matter results in an acidic, sandy, organic-rich soil.

Natural Processes

The vertical structure of cliffs causes constant erosion and restricts soil development to the cliff edge, ledges, crevices, and the base of the cliff where organic matter and sandy particles can accumulate. The thin soils and direct exposure to wind, ice, and sun produce desiccating conditions that limit plant growth. However, cliff aspect and local seepages result in a variability of site moisture conditions. North- and east-facing cliffs are typically moister than south- and west-facing cliffs because of reduced wind and reduced direct exposure to the sun. Moisture can be locally present on cliff faces due to local groundwater seepages along the cliff face and surface flow across the cliff during rain events or snow melt. In addition, fog occurs regularly on the coast, fostering the growth of moss and lichen. Windthrown trees are common along the tops of cliffs due to strong lake winds and shallow soils. Windblown trees at the base of the cliff provide localized areas for soil accumulation. Sandstone cliff faces regularly break free, forming blocky

talus at the base of many of the sandstone cliffs and exposing fresh, bare rock substrates. Cliff faces are scoured by ice and waves, further increasing rates of erosion.

Vegetation

While mosses, lichens, and liverworts can be common on the exposed cliff face, vascular plant cover is sparse, being generally restricted to the flat, exposed bedrock at the upper edge of the cliff (i.e., lip), ledges, crevices in the cliff face, and along the cliff base if a ledge of talus, cobble, sand, or bedrock is present between the cliff and the open water. Mosses, lichens, and liverworts are dominant in groundwater seepage areas along the cliff face, where streams pass over the cliff face, and where cliff faces overhang the water. Common herbaceous species associated with sandstone lakeshore cliff include fragile fern (*Cystopteris fragilis*), northern beech fern (*Thelypteris phegopteris*), lady fern (*Athyrium filix-femina*), spinulose woodfern (*Dryopteris carthusiana*), hair grass (*Deschampsia cespitosa*), yarrow (*Achillea millefolium*), fireweed (*Epilobium angustifolium*), wild strawberry (*Fragaria virginiana*), harebell (*Campanula rotundifolia*), common horsetail (*Equisetum arvense*), grass-leaved goldenrod (*Euthamia graminifolia*), hairy hawkweed (*Hieracium gronovii*), marsh violet (*Viola cucullata*), marsh pea (*Lathyrus palustris*), jewelweed (*Impatiens capensis*), northern bugleweed (*Lycopus uniflorus*), and two invasive plants, pearlwort (*Sagina procumbens*) and Canada bluegrass (*Poa compressa*). Common shrubs include ninebark (*Physocarpus opulifolius*), dwarf raspberry (*Rubus pubescens*), wild red raspberry (*R. strigosus*), mountain alder (*Alnus crispa*), bush honeysuckle (*Diervilla lonicera*), cherries (*Prunus* spp.), serviceberries (*Amelanchier* spp.), and willows (*Salix* spp.). Scattered and stunted trees are restricted to ledges and crevices and include paper birch (*Betula papyrifera*), white spruce (*Picea glauca*), northern white-cedar (*Thuja occidentalis*), balsam fir (*Abies balsamea*), and quaking aspen (*Populus tremuloides*). Trees occurring at the top of the cliff include sugar maple (*Acer saccharum*), paper birch, white spruce, balsam poplar (*Populus balsamifera*), white pine (*Pinus strobus*), northern white-cedar, and hemlock (*Tsuga canadensis*).

Many of the Jacobsville Sandstone sites have blocky talus at the base of the cliffs, while talus is absent on most Freda Sandstone sites. The talus supports almost no vegetation, probably due to frequent inundation and severe storm waves. The cliff face is largely unvegetated, except within cracks, on ledges, and where there are seepages or small streams crossing the rock surface. In these moist areas mosses, lichens, and grasses often form thick vegetation beds. The density and diversity of the vegetation of sandstone lakeshore cliffs tend to be greater along lower escarpments. The tops of the cliffs are typically boreal forest but can include dry-mesic northern forest, mesic northern forest, and less frequently forested wetland.

Noteworthy Animals

Cliffs provide nesting habitat for raptors and common ravens (*Corvus corax*).

Rare Plants

Carex atratifformis (sedge, state threatened)
Empetrum nigrum (black crowberry, state threatened)
Gymnocarpium robertianum (limestone oak fern, state threatened)
Pinguicula vulgaris (butterwort, state special concern)
Salix pellita (satiny willow, state special concern)
Salix planifolia (tea-leaved willow, state threatened)
Senecio indecorus (rayless mountain ragwort, state threatened)
Trisetum spicatum (downy oat-grass, state special concern)
Vaccinium cespitosum (dwarf bilberry, state threatened)

Rare Animals

Falco columbarius (merlin, state threatened)

Falco peregrinus (peregrine falcon, state endangered)

Haliaeetus leucocephalus (bald eagle, state special concern)

Biodiversity Management Considerations

Threats to lakeshore cliffs include shoreline development, logging of adjacent uplands and associated soil erosion, excessive foot traffic along the upper edge, and invasive plants. The thin soils and unstable environment make soil development and plant reestablishment slow, highlighting the importance of minimizing logging and excessive trampling along the upper edge of cliffs. Maintaining a mature, unfragmented forested buffer around sandstone lakeshore cliffs may help limit the local seed source for invasive species distributed by wind or birds. Some of the invasive plants that may threaten the biodiversity of sandstone lakeshore cliffs include spotted knapweed (*Centaurea maculosa*), ox-eye daisy (*Chrysanthemum leucanthemum*), sheep sorrel (*Rumex acetosella*), hawkweeds (*Hieracium* spp.), Kentucky bluegrass (*P. pratensis*), Canada bluegrass, and pearlwort. Monitoring and control efforts to detect and remove these and other invasive species will help maintain the ecological integrity of sandstone lakeshore cliff and surrounding natural communities.

Variation

The sandstone bedrock along Lake Superior varies significantly in texture and erosion resistance, which influence vegetative composition and structure. Some of the sandstone cliffs grade into much finer siltstone.

Similar Natural Communities

Volcanic lakeshore cliff, granite lakeshore cliff, limestone lakeshore cliff, granite cliff, limestone cliff, sandstone cliff, volcanic cliff, granite bedrock glade, volcanic bedrock glade, sandstone bedrock lakeshore, and sandstone cobble shore.

Relevant Literature

Albert, D.A., P. Comer, D. Cuthrell, D. Hyde, W. MacKinnon, M. Penskar, and M. Rabe. 1997. The Great Lakes bedrock lakeshores of Michigan. Michigan Natural Features Inventory, Lansing, MI. 218 pp.

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LaBerge, G.L. 1994. Geology of the Lake Superior region. Geoscience Press, Phoenix, AZ. 313 pp.

Reed, R.C., and J. Daniels. 1987. Bedrock geology of northern Michigan. State of Michigan Department of Natural Resources. Map: 1: 500,000.

For a full list of references used to create this description, please refer to the natural community abstract for sandstone lakeshore cliff.

Granite Lakeshore Cliff

Global/State Rank: GU/S1

Overview

Granite lakeshore cliff consists of vertical or near-vertical exposures of bedrock with sparse coverage of vascular plants, lichens, mosses, and liverworts. The community occurs in the western Upper Peninsula along Lake Superior and is characterized by high site moisture due to its proximity to Lake Superior and a stressed and unstable environment because of severe waves, wind, and winter ice.

Landscape Context

A broad range of igneous and metamorphic rock, including gneiss, schist, granite, and quartzite, are often loosely referred to as “granitic” or “granite.” Along Lake Superior in the western Upper Peninsula, small exposed knobs of the older granitic bedrock are typically surrounded by long expanses of younger, more recently formed Jacobsville Sandstone cliffs. In Michigan, scattered exposures of granitic cliffs are limited to a 80 km (50 mile) stretch of the Lake Superior shoreline in Marquette County from the Huron Islands in the west to just east of Marquette. The community is also present along the Minnesota and Ontario shorelines of Lake Superior. Along its inland margin, granite lakeshore cliff is typically bordered by boreal forest, dry-mesic northern forest, mesic northern forest, or granite bedrock glade. Along the shoreline, the community is interspersed with areas of granite bedrock lakeshore, sandstone lakeshore cliff, volcanic cobble shore, and sand and gravel beach.

Soils

Soil development is limited to organic soils that form from decaying roots and other plant material that accumulates in cracks, crevices, and depressions in the bedrock, primarily along the cliff summit. The thin organic soils are acidic.

Natural Processes

The combination of strong winds, waves, ice, and bedrock exfoliation maintain open conditions on the cliff face. The thin soils and full exposure to wind, ice, and sun produce desiccating conditions for many plants. Abundant fog provides moisture for the establishment of mosses and lichens on more protected rock surfaces, while vascular plants are restricted to crevices or moisture-holding depressions in the rock. Granitic rock, formed under intense pressure deep within the earth’s crust, exfoliates when it is exposed at the surface. Exfoliation adds to the instability of the ecosystem, reducing dependable habitat for plant establishment. As portions of the bedrock slough off, they form talus slopes along the shore at the base of the cliff (if a ledge is present at the cliff base) and expose fresh, bare rock substrates.

Vegetation

While mosses and lichens can be common on the exposed cliff face, vascular plant cover is sparse, being generally restricted to the flat, exposed bedrock at the upper edge of the cliff (i.e., lip), cracks and crevices in the cliff face, and along the cliff base if a ledge of talus, cobble, sand, or bedrock is present between the cliff and the open water. At the upper edge of the cliff, there are often krummholz (i.e., low, misshapen) or flagged white pine (*Pinus strobus*), jack pine (*P. banksiana*), and red pine (*P. resinosa*). Paper birch (*Betula papyrifera*), quaking aspen (*Populus tremuloides*), and serviceberries (*Amelanchier* spp.) also occur in this zone. Characteristic shrubs include low sweet blueberry (*Vaccinium angustifolium*), bearberry (*Arctostaphylos uva-ursi*),

common juniper (*Juniperus communis*), and bush honeysuckle (*Diervilla lonicera*). Among the more common plants of the sparse ground layer are hair grass (*Deschampsia cespitosa*), poverty grass (*Danthonia spicata*), three-toothed cinquefoil (*Potentilla tridentata*), and large-leaved aster (*Aster macrophyllus*). The top of the cliff is often an open glade, with scattered, open-grown, flagged trees growing on bedrock or thin soil. Fissures along the cliff face and ledges can support scattered clumps of vegetation. Typical species include grass-leaved goldenrod (*Euthamia graminifolia*), hair grass, bearberry, common juniper, serviceberries, and stunted white pine and paper birch.

Noteworthy Animals

Cliffs provide nesting habitat for raptors and common ravens (*Corvus corax*).

Rare Plants

Dryopteris filix-mas (male fern, state special concern)

Trisetum spicatum (downy oat-grass, state special concern)

Rare Animals

Falco columbarius (merlin, state threatened)

Falco peregrinus (peregrine falcon, state endangered)

Haliaeetus leucocephalus (bald eagle, state special concern)

Biodiversity Management Considerations

Threats to lakeshore cliffs include shoreline development, logging of adjacent uplands and associated soil erosion, excessive foot traffic along the upper edge, and invasive plants. The thin soils and unstable environment make soil development and plant reestablishment slow, highlighting the importance of minimizing logging and excessive trampling along the upper edge of cliffs. Maintaining a mature, unfragmented forested buffer around granite lakeshore cliffs may help limit the local seed source for invasive species distributed by wind or birds. Some of the invasive plants that may threaten the biodiversity of granite lakeshore cliffs include spotted knapweed (*Centaurea maculosa*), ox-eye daisy (*Chrysanthemum leucanthemum*), Canada bluegrass (*Poa compressa*), Kentucky bluegrass (*P. pratensis*), sheep sorrel (*Rumex acetosella*), and hawkweeds (*Hieracium* spp.). Monitoring and control efforts to detect and remove these and other invasive species will help maintain the ecological integrity of granite lakeshore cliff and surrounding natural communities.

Variation

Several types of bedrock are included within this plant community. On Lake Superior in Michigan, this includes granites, gneisses, quartzite, and probably several other types of metamorphic rock.

Similar Natural Communities

Volcanic lakeshore cliff, sandstone lakeshore cliff, limestone lakeshore cliff, granite cliff, limestone cliff, sandstone cliff, volcanic cliff, granite bedrock glade, granite bedrock lakeshore, and volcanic bedrock glade.

Relevant Literature

Albert, D.A., P. Comer, D. Cuthrell, D. Hyde, W. MacKinnon, M. Penskar, and M. Rabe. 1997. The Great Lakes bedrock lakeshores of Michigan. Michigan Natural Features Inventory, Lansing, MI. 218 pp.

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- LaBerge, G.L. 1994. *Geology of the Lake Superior region*. Geoscience Press, Phoenix, AZ. 313 pp.
- Reed, R.C., and J. Daniels. 1987. *Bedrock geology of northern Michigan*. State of Michigan Department of Natural Resources. Map: 1: 500,000.

Volcanic Lakeshore Cliff

Global/State Rank: GU/S1

Overview

Volcanic lakeshore cliffs consist of vertical or near-vertical exposures of bedrock, which support less than 25% vascular plant coverage, although lichens, mosses, and liverworts are abundant on some rock surfaces. The cliffs range in height from 3 to 80 meters (10 to 260 ft) and occur on Lake Superior along the Keweenaw Bay shoreline of the Keweenaw Peninsula and along the northern shoreline of Isle Royale. Volcanic lakeshore cliffs are characterized by high site moisture due to the proximity to Lake Superior and a stressed and unstable environment because of severe waves, wind, and winter ice.

Landscape Context

The bedrock of the Keweenaw Peninsula dips steeply toward the north and into Lake Superior, while the south face of the bedrock forms cliffs. In most places, the cliffs are only a few meters high, but near Bete Grise the cliffs are nearly 80 m (260 ft) high. Cliffs occur along large stretches of the 32 km (20 mile)-long southern shoreline of the Keweenaw Peninsula and Manitou Island between Bete Grise to the Manitou Island lighthouse at the east end of the island. Volcanic rock cliffs similarly form the north shoreline of Isle Royale. On the Keweenaw Peninsula, most of the cliffs are formed of massive basalt, but there are also some areas of cliff composed of volcanic conglomerate rock. Volcanic lakeshore cliff also occurs on the shorelines of Lake Superior in Ontario and Minnesota. In Michigan, volcanic lakeshore cliff is typically bordered by boreal forest and occasionally by dry-mesic northern forest, mesic northern forest, or volcanic bedrock glade. Along the shoreline, volcanic lakeshore cliffs are interspersed with areas of volcanic bedrock lakeshore, volcanic cobble shore, and sand and gravel beach.

Soils

There is little soil development on the steep rock face of the cliffs. Some organic soil development occurs in crevices in the rock face and on the upper lip of the cliffs.

Natural Processes

The cliffs are exposed to almost continual wave action from Lake Superior. During winter, ice adds to the erosive environment along the shore, both for the cliff and the upland forest along the cliff edge. Storm winds off Lake Superior uproot trees and erode soils. Windblown trees at the base of the cliff provide localized areas for soil accumulation. Thin soils, winter winds, full exposure, and summer droughts produce a desiccating environment for plants. The regularly occurring fog along the coast serves to somewhat mitigate these desiccating effects during the growing season.

Vegetation

While mosses and lichens are common on the exposed cliff face, vascular plant cover is sparse, being generally restricted to the flat, exposed bedrock at the upper edge of the cliff (i.e., lip), cracks and joints in the cliff face, and along the cliff base if a ledge of talus, cobble, sand, or bedrock is present between the cliff and the open water. The upper edge of the cliff is typically backed by boreal forest, with abundant windthrown trees resulting from strong lake winds. Herbaceous species characteristic of the upper flat edge or lip include downy oat-grass (*Trisetum spicatum*, state special concern), harebell (*Campanula rotundifolia*), upland white goldenrod (*Solidago ptarmicoides*), Gillman's goldenrod (*S. simplex*), balsam ragwort (*Senecio*

pauperculus), wild strawberry (*Fragaria virginiana*), yarrow (*Achillea millefolium*), hair grass (*Deschampsia cespitosa*), and the invasive species Canada bluegrass (*Poa compressa*). Shrubs occurring along the upper lip include mountain alder (*Alnus crispa*), soapberry (*Shepherdia canadensis*), serviceberries (*Amelanchier* spp.), and wild rose (*Rosa acicularis*). Some of the few plants that occur on the cliff face are occasional patches of common polypody (*Polypodium virginianum*), harebell, and hair grass. Dense, shrubby stands of white spruce (*Picea glauca*), northern white-cedar (*Thuja occidentalis*), paper birch (*Betula papyrifera*), mountain ash (*Sorbus decora*), and balsam fir (*Abies balsamea*) form the coastal boreal forest along the edge of the cliff.

Noteworthy Animals

Cliffs provide nesting habitat for raptors and the common ravens (*Corvus corax*).

Rare Plants

Arnica lonchophylla (longleaf arnica, state endangered)

Castilleja septentrionalis (pale Indian paintbrush, state threatened)

Polygonum viviparum (alpine bistort, state threatened)

Trisetum spicatum (downy oat-grass, state special concern)

Rare Animals

Falco columbarius (merlin, state threatened)

Falco peregrinus (peregrine falcon, state endangered)

Haliaeetus leucocephalus (bald eagle, state special concern)

Biodiversity Management Considerations

Threats to lakeshore cliffs include shoreline development, logging of adjacent uplands and associated soil erosion, excessive foot traffic along the upper edge, and invasive plants. The thin soils and unstable environment make soil development and plant reestablishment slow, highlighting the importance of minimizing logging and excessive trampling along the upper edge of cliffs. Maintaining a mature, unfragmented forested buffer around volcanic lakeshore cliff may help limit the local seed source for invasive species distributed by wind or birds. Some of the invasive plants that may threaten the diversity and structure of volcanic lakeshore cliffs include spotted knapweed (*Centaurea maculosa*), ox-eye daisy (*Chrysanthemum leucanthemum*), Canada bluegrass, Kentucky bluegrass (*P. pratensis*), sheep sorrel (*Rumex acetosella*), and hawkweeds (*Hieracium* spp.). Monitoring and control efforts to detect and remove these and other invasive species will help maintain the ecological integrity of volcanic lakeshore cliff and surrounding natural communities.

Variation

Volcanic lakeshore cliffs occur on both volcanic conglomerate and massive basalt. Vegetation diversity appears to be higher on the conglomerate substrate.

Similar Natural Communities

Granite lakeshore cliff, sandstone lakeshore cliff, limestone lakeshore cliff, granite cliff, limestone cliff, sandstone cliff, volcanic cliff, volcanic bedrock glade, granite bedrock glade, volcanic bedrock lakeshore, and northern bald.

Relevant Literature

- Albert, D.A., P. Comer, D. Cuthrell, D. Hyde, W. MacKinnon, M. Penskar, and M. Rabe. 1997. The Great Lakes bedrock lakeshores of Michigan. Michigan Natural Features Inventory, Lansing, MI. 218 pp.
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INLAND CLIFF COMMUNITIES

Limestone Cliff

Global/State Rank: G4G5/S2

Overview

Limestone cliff consists of vertical or near-vertical exposures of bedrock, which typically support less than 25% vascular plant coverage, although some rock surfaces can be densely covered with lichens, mosses, and liverworts. The community occurs predominantly in the Upper Peninsula, most typically within a few kilometers of the Lake Michigan and Lake Huron shorelines, on the Niagaran Escarpment and Cuesta, but with isolated occurrences of much older Precambrian-aged limestones and dolomites in the western Upper Peninsula. Limestone cliffs also occur within sinkholes within Devonian Limestone in the northern Lower Peninsula. Like most of Michigan's cliffs, vegetation cover is sparse, but abundant cracks and crevices combined with calcareous conditions result in greater plant diversity and coverage than on most other cliff types.

Landscape Context

Limestone and dolomite cliffs are scattered along the Niagaran Escarpment, from the Garden Peninsula on northwestern Lake Michigan to Mackinac and Drummond Islands in northern Lake Huron. On the Niagaran Escarpment, limestone cliffs extend southwest onto the Door Peninsula of Wisconsin and east to the Bruce Peninsula in Ontario, and farther east into New York. In the western Upper Peninsula, limestone cliffs are quite localized in Houghton County west of L'Anse and south of Marquette in Marquette County. Karst features, such as sinkholes, occur in the Devonian-aged limestone of Presque Isle and Alpena counties, and there are small cliffs near the Lake Huron shoreline in both counties as well. Limestone cliffs also occur in Vermont and New Hampshire. In the Upper Peninsula of Michigan, limestone cliff is typically bordered along its margins by boreal forest, mesic northern forest, or occasionally by dry-mesic northern forest.

Soils

Soil development is primarily limited to thin organic soils that form from decaying roots and other plant materials along the top of the cliff escarpment and ledges, in cracks and crevices in the bedrock, and at the base of the cliff. Breakdown of limestone and plant debris results in a sandy to loamy, organic-rich soil, with mildly alkaline to alkaline pH.

Natural Processes

The vertical structure of cliffs causes constant erosion and restricts soil development to the cliff edge, cracks, ledges, and the base of the cliff where organic matter and soil particles can accumulate. The thin soils and direct exposure to wind, ice, and sun produce desiccating conditions that limit plant growth. However, cliff aspect and local seepages result in a variability of site moisture conditions. North- and east-facing cliffs are typically moister than south- and west-facing cliffs because of reduced wind and reduced direct exposure to the sun. Moisture can be locally present on cliff faces due to local groundwater seepage along the cliff face or surface flow across the cliff face during rain events or snow melt. In addition, where limestone cliff occurs close to the Great Lakes, a moderated climate generates moist conditions along the cliff face. Weathering results in the gradual exfoliation of limestone along the cliff face, which adds to the instability of the ecosystem, reducing dependable habitat for plant establishment. As portions of the bedrock slough off, they form talus slopes along the base of cliffs and expose fresh, bare

rock substrates along the cliff face. Windthrow of canopy trees along the cliff escarpment is common due to the thin soils, unstable substrate, and high wind activity. Windblown trees along ledges and at the base of the cliff provide localized areas for soil accumulation.

Vegetation

While lichens, mosses, and liverworts are common on the exposed cliff face, vascular plant cover is sparse, being generally restricted to the flat, exposed bedrock at the upper edge of the cliff (i.e., lip), cracks, joints, and ledges in the cliff face, and cliff base, where a talus slope typically accumulates. Lichens, mosses, and liverworts are especially abundant on moist seepages and cooler north aspects. Among the most common trees on the forested ridge tops are sugar maple (*Acer saccharum*), northern white-cedar (*Thuja occidentalis*), and balsam fir (*Abies balsamea*). Common herbaceous plants occurring at the cliff edge and in the cliff-top and cliff-base forests include common polypody (*Polypodium virginianum*), large-leaved aster (*Aster macrophyllus*), Canada mayflower (*Maianthemum canadense*), wild strawberry (*Fragaria virginiana*), starflower (*Trientalis borealis*), and wild sarsaparilla (*Aralia nudicaulis*). On the open cliff face, vegetation cover is sparse and confined to ledges and cracks. Common tree species on the cliff face are northern white-cedar and paper birch (*Betula papyrifera*), both species that root in crevices in the rock. Balsam fir is often present in the subcanopy and understory. Common herbs on the cliff face include grass-leaved goldenrod (*Euthamia graminifolia*) and herb Robert (*Geranium robertianum*). Ferns are prevalent along the cliff face, especially along moist exposures. Characteristic ferns include common polypody, fragile fern (*Cystopteris fragilis*), smooth cliff brake (*Pellaea glabella*), maidenhair spleenwort (*Asplenium trichomanes*), bracken fern (*Pteridium aquilinum*), Oregon woodsia (*Woodsia oregana*), and wall-rue (*Asplenium ruta-muraria*, state endangered). Common shrubs on the cliffs include soapberry (*Shepherdia canadensis*), bush honeysuckle (*Diervilla lonicera*), Canada yew (*Taxus canadensis*), mountain maple (*Acer spicatum*), and red elderberry (*Sambucus racemosa*). Shrubs such as round-leaved dogwood (*Cornus rugosa*), mountain maple, and red elderberry grow on the talus at the base of the cliff. Several invasive plants commonly establish on or near limestone cliffs, including common mullein (*Verbascum thapsus*), hound's-tongue (*Cynoglossum officinale*), bittersweet nightshade (*Solanum dulcamara*), chickweed (*Cerastium glomeratum*), and ox-eye daisy (*Chrysanthemum leucanthemum*). Recently, cryptoendolithic species of algae have been found to grow within the structure of the rock, creating the dark surface color of limestone rock.

Studies of limestone cliffs in Ontario found that there were three distinct zones of vegetation that share few species: ridge-top forest, cliff face, and talus. This zonation is also apparent in many Michigan limestone cliff systems; however, where the vertical height of the cliffs is low, there is a significant amount of overlap in terms of species composition among the zones.

Noteworthy Animals

Large crevices in cliffs provide hibernacula for bats (*Myotis* spp.) and snakes, including eastern garter snake (*Thamnophis s. sirtalis*), western fox snake (*Elaphe vulpna*), and northern ring-necked snake (*Diadophis punctatus edwardsii*). Birds found commonly nesting on limestone and dolomite cliffs include American goldfinch (*Carduelis tristis*), Nashville warbler (*Vermivora ruficapilla*), and cliff swallow (*Petrochelidon pyrrhonota*). White-footed mouse (*Peromyscus leucopus*), deer mouse (*P. maniculatus*), and raccoon (*Procyon lotor*) also commonly utilize the cliffs. Eastern chipmunks (*Tamias striatus*) and other rodents burrow and nest in the protected habitat of the talus. Caddisflies (*Trichoptera*), mosquitoes (*Culicidae*), and solitary midges (*Thaumaleidae*) are found associated with continuous seepage areas on cliffs, and many species of spider (*Arachnida*) are common as well.

Rare Plants

Asplenium rhizophyllum (walking fern, state threatened)
Asplenium ruta-muraria (wall-rue, state endangered)
Asplenium scolopendrium var. *americanum* (Hart's-tongue fern, state endangered)
Asplenium trichomanes-ramosum (green spleenwort, state special concern)
Astragalus neglectus (Cooper's milk vetch, state special concern)
Braya humilis (low northern rock cress, state threatened)
Cystopteris tennesseensis (Tennessee bladder fern, state threatened)
Danthonia intermedia (wild oat-grass, state special concern)
Draba arabisans (rock whitlow-grass, state special concern)
Draba cana (ashy whitlow-grass, state threatened)
Dryopteris filix-mas (male fern, state special concern)
Pellaea atropurpurea (purple cliff-brake, state threatened)
Woodsia alpina (northern woodsia, state endangered)
Woodsia obtusa (blunt-lobed woodsia, state threatened)

Rare Animals

Falco columbarius (merlin, state threatened)
Falco peregrinus (Peregrine falcon, state endangered)
Gastrocopta holzingeri (lambda snaggletooth, endangered)
Guppya sterki (Sterki's granule, state endangered)
Haliaeetus leucocephalus (bald eagle, state special concern)
Hendersonia occulta (cherrystone drop, state special concern)
Planogyra asteriscus (eastern flat-whorl, state special concern)
Vallonia gracilicosta albula (land snail, state endangered)
Vertigo bollesiana (delicate vertigo, state threatened)
Vertigo cristata (land snail, state special concern)
Vertigo paradoxa (land snail, state special concern)

Biodiversity Management Considerations

Threats to cliffs include logging of adjacent uplands and associated soil erosion, excessive foot traffic along the upper edge, rock climbing, and invasive plants. The thin soils and unstable cliff environment make soil development and plant reestablishment slow, highlighting the importance of minimizing logging and excessive trampling along the upper edge of cliffs. Rock climbing can result in damage and loss of vegetation on cliff faces, as many lichens and mosses of the cliffs have extremely slow recovery rates. Maintaining a mature, unfragmented forested buffer around limestone cliff may help limit the local seed source for invasive species distributed by wind or birds. Some of the invasive plants that may threaten diversity and structure of limestone cliffs include spotted knapweed (*Centaurea maculosa*), chickweed, ox-eye daisy, Canada bluegrass (*Poa compressa*), Kentucky bluegrass (*P. pratensis*), sheep sorrel (*Rumex acetosella*), hawkweeds (*Hieracium* spp.), common mullein, hound's-tongue, and bittersweet nightshade. Monitoring and control efforts to detect and remove these and other invasive species will help maintain the ecological integrity of limestone cliff and surrounding natural communities.

Variation

The limestone is quite variable across the Niagaran Escarpment, including magnesium-rich limestone (i.e., dolomite) and argillaceous, or muddy limestone. These chemical differences result in different physical appearance and characteristics, such as hardness and amount and size of crevices. These physical and chemical differences translate to different habitat characteristics and species composition.

Similar Natural Communities

Limestone lakeshore cliff, sandstone cliff, sandstone lakeshore cliff, volcanic cliff, volcanic lakeshore cliff, granite cliff, granite lakeshore cliff, limestone bedrock glade, and northern bald.

Relevant Literature

- Albert, D.A., P. Comer, D. Cuthrell, D. Hyde, W. MacKinnon, M. Penskar, and M. Rabe. 1997. The Great Lakes bedrock lakeshores of Michigan. Michigan Natural Features Inventory, Lansing, MI. 218 pp.
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Sandstone Cliff

Global/State Rank: G4G5/S2

Overview

Sandstone cliff consists of vertical or near-vertical exposures of bedrock with sparse coverage of vascular plants, lichens, mosses, and liverworts. The community occurs in the central and western Upper Peninsula, and locally in Eaton County in the southern Lower Peninsula.

Landscape Context

Sandstone cliffs occur as part of several geologic formations, including the Copper Harbor Conglomerate, Jacobsville Sandstone, and Nonesuch and Freda Formations in the western Upper Peninsula. In the southern Lower Peninsula, sandstone cliffs of Eaton Sandstone are restricted to one area along the Grand River near Grand Ledge. Sandstone cliff is typically bordered along its inland margin by boreal forest, dry-mesic northern forest, mesic northern forest, and occasionally by forested wetlands. In Eaton County, the cliffs are bordered by dry-mesic southern forest and mesic southern forest.

Soils

There is almost no soil development on the cliffs except for shallow organic soil development along the narrow cliff summit and in crevices in the cliff face where sand particles, decaying roots, and plant debris accumulate. The breakdown of sandstone and plant matter results in an acidic, sandy, organic-rich soil.

Natural Processes

The vertical structure of cliffs causes constant erosion and restricts soil development to crevices where organic matter and soil particles can accumulate. The thin soils and direct exposure to wind, ice, and sun produce desiccating conditions that limit plant growth. However, cliff aspect and local seepages result in a variability of site moisture conditions. North- and east-facing cliffs are typically moister than south- and west-facing cliffs, because of reduced wind and reduced direct exposure to the sun. Moisture can be locally present on cliff faces due to local groundwater seepages along the cliff face and surface flow across the cliff during rain events or snow melt. Windthrown trees are common along the tops of cliffs due to strong winds and shallow soils. Windblown trees at the base of the cliff provide localized areas for soil accumulation. Sandstone cliff faces regularly break free, forming blocky talus at the base of many of the sandstone cliffs and exposing fresh, bare rock substrates.

Vegetation

While mosses, lichens, and liverworts can be common on the exposed cliff face, vascular plant cover is sparse, being generally restricted to the flat, exposed bedrock at the upper edge of the cliff (i.e., lip), crevices in the cliff face, and along the cliff base, where a slope of blocky talus typically develops. Mosses, lichens, and liverworts are dominant in groundwater seepage areas along the cliff face. Common herbaceous species associated with sandstone cliff include fragile fern (*Cystopteris fragilis*), northern beech fern (*Thelypteris phegopteris*), lady fern (*Athyrium filix-femina*), spinulose woodfern (*Dryopteris carthusiana*), yarrow (*Achillea millefolium*), fireweed (*Epilobium angustifolium*), wild strawberry (*Fragaria virginiana*), harebell (*Campanula rotundifolia*), common horsetail (*Equisetum arvense*), grass-leaved goldenrod (*Euthamia graminifolia*), hairy hawkweed (*Hieracium gronovii*), marsh violet (*Viola cucullata*), and two invasive plants, pearlwort (*Sagina procumbens*) and Canada bluegrass (*Poa compressa*).

Common shrubs include ninebark (*Physocarpus opulifolius*) and dwarf raspberry (*Rubus pubescens*). Trees commonly occurring at the top of the cliff include sugar maple (*Acer saccharum*), paper birch (*Betula papyrifera*), white spruce (*Picea glauca*), balsam poplar (*Populus balsamifera*), northern white-cedar (*Thuja occidentalis*), and hemlock (*Tsuga canadensis*). The one southern example of this community at Grand Ledge also supports an overstory of sugar maple, with witch-hazel (*Hamamelis virginiana*) and bush honeysuckle (*Diervilla lonicera*) as common shrubs, and common polypody (*Polypodium virginianum*) the most prevalent fern.

Noteworthy Animals

Cliffs provide nesting habitat for raptors and common ravens (*Corvus corax*).

Rare Plants

Carex atratiformis (sedge, state threatened)

Empetrum nigrum (black crowberry, state threatened)

Gymnocarpium robertianum (limestone oak fern, state threatened)

Senecio indecorus (rayless mountain ragwort, state threatened)

Vaccinium cespitosum (dwarf bilberry, state threatened)

Rare Animals

Falco columbarius (merlin, state threatened)

Falco peregrinus (peregrine falcon, state endangered)

Haliaeetus leucocephalus (bald eagle, state special concern)

Biodiversity Management Considerations

Threats to sandstone cliffs include logging of adjacent uplands and associated soil erosion, excessive foot traffic along the upper edge of the cliff, and invasive plants. The thin soils and an unstable environment make soil development and plant reestablishment slow, highlighting the importance of minimizing logging and excessive trampling along the upper edge of cliffs. Maintaining a mature, unfragmented forested buffer around sandstone cliff may help limit the local seed source for invasive species distributed by wind or birds. Some of the invasive plants that may threaten the biodiversity of sandstone cliffs include spotted knapweed (*Centaurea maculosa*), ox-eye daisy (*Chrysanthemum leucanthemum*), sheep sorrel (*Rumex acetosella*), hawkweeds (*Hieracium* spp.), Kentucky bluegrass (*P. pratensis*), Canada bluegrass, and pearlwort. Monitoring and control efforts to detect and remove these and other invasive species will help maintain the ecological integrity of sandstone cliff and surrounding natural communities.

Variation

The sandstone bedrock varies significantly in texture and erosion resistance, which influences soil development and vegetation establishment. The single southern occurrence at Grand Ledge supports a more southern flora.

Similar Natural Communities

Granite cliff, limestone cliff, volcanic cliff, sandstone lakeshore cliff, granite lakeshore cliff, limestone lakeshore cliff, volcanic lakeshore cliff, granite bedrock glade, volcanic bedrock glade, and northern bald.

Relevant Literature

- Albert, D.A., P. Comer, D. Cuthrell, D. Hyde, W. MacKinnon, M. Penskar, and M. Rabe. 1997. The Great Lakes bedrock lakeshores of Michigan. Michigan Natural Features Inventory, Lansing, MI. 218 pp.
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- Dorr, J.A., Jr., and D.F. Eschman. 1970. Geology of Michigan. University of Michigan Press, Ann Arbor, MI. 470 pp.
- Faber-Langendoen, D., ed. 2001. Plant communities of the Midwest: Classification in an ecological context. Association for Biodiversity Information, Arlington, VA. 61 pp. + appendix (705 pp.).
- LaBerge, G.L. 1994. Geology of the Lake Superior region. Geoscience Press, Phoenix, AZ. 313 pp.
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- Reed, R.C., and J. Daniels. 1987. Bedrock geology of northern Michigan. State of Michigan Department of Natural Resources. Map: 1: 500,000.

Granite Cliff

Global/State Rank: G4G5/S2

Overview

Granite cliff consists of vertical or near-vertical exposures of bedrock with sparse coverage of vascular plants, lichens, mosses, and liverworts. The community occurs in several counties of the western Upper Peninsula, including Dickinson, Gogebic, Houghton, Iron, Marquette, and Menominee.

Landscape Context

A broad range of igneous and metamorphic rock, including gneiss, schist, granite, and quartzite, are often loosely referred to as “granitic” or “granite.” Granite cliff is composed of resistant igneous and metamorphic bedrock types of the Michigan Highlands that formed during the Precambrian Era, approximately 3,500 to 600 million years ago. The community is also present in nearby Wisconsin, Minnesota, and Ontario. Along its margins, granite cliff is typically bordered by boreal forest, dry-mesic northern forest, mesic northern forest, or granite bedrock glade. Wetlands sometimes occur at the base of cliffs and include rich conifer swamp, poor conifer swamp, and northern shrub thicket. Cliff exposures that occur along Lake Superior are classified as granite lakeshore cliff. Among the largest expanses of inland cliffs is Mulligan Cliffs in Marquette County, which is several miles long and ranges in height from 22 to 46 m (60 to 130 feet).

Soils

Soil development is limited to shallow organic soils that form from decaying roots and other plant material that accumulates in cracks, crevices, ledges, and flat areas or depressions in the bedrock. Soils accumulate primarily along the cliff summit, on talus slopes, and at the base of the cliff. The thin organic soils are typically acid but can range from slightly acid to slightly alkaline depending on the rock type.

Natural Processes

The combination of vertical exposure, thin soils, strong winds, ice, and bedrock exfoliation maintain open conditions on the cliff face. The thin soils and full exposure to wind and sun produce desiccating conditions for many plants. Mosses and lichens establish on more protected rock surfaces, while vascular plants are restricted to crevices, ledges, or moisture-holding depressions in the rock. Granitic rock, formed under intense pressure deep within the earth’s crust, exfoliates when it is exposed at the surface. Exfoliation adds to the instability of the ecosystem, reducing dependable habitat for plant establishment. As portions of the bedrock slough off, they form talus slopes along the base of cliffs and expose fresh, bare rock substrates along the cliff face. Windthrow of canopy trees along the cliff escarpment is common due to the thin soils, unstable substrate, and high wind activity. Windblown trees along ledges and at the base of the cliff provide localized areas for soil accumulation. In addition, lightning strikes can generate localized fires along the cliff face and also at the base of the cliff where conifer canopy is most prevalent.

Vegetation

While mosses and lichens can be common on the exposed cliff face, vascular plant cover is sparse, being generally restricted to the flat, exposed bedrock at the upper edge of the cliff (i.e., lip), cracks and crevices in the cliff face, ledges, and terraces that interrupt the vertical exposure,

and along the cliff base, where a talus slope typically develops. Prevalent canopy species along the cliff face include white pine (*Pinus strobus*), jack pine (*P. banksiana*), and red pine (*P. resinosa*), with canopy associates including red oak (*Quercus rubra*) and big-toothed aspen (*Populus grandidentata*). At the upper edge of the cliff, there can be krummholz (i.e., low, misshapen) or flagged trees. Paper birch (*Betula papyrifera*), choke cherry (*Prunus virginiana*), and serviceberries (*Amelanchier* spp.) also occur in this zone. Characteristic shrubs include low sweet blueberry (*Vaccinium angustifolium*), bearberry (*Arctostaphylos uva-ursi*), common juniper (*Juniperus communis*), and bush honeysuckle (*Diervilla lonicera*). Among the more common plants of the sparse ground layer are hair grass (*Deschampsia cespitosa*), poverty grass (*Danthonia spicata*), three-toothed cinquefoil (*Potentilla tridentata*), bracken fern (*Pteridium aquilinum*), Canada mayflower (*Maianthemum canadense*), and large-leaved aster (*Aster macrophyllus*). The top of the cliff is often an open glade, with scattered, open-grown, and occasionally flagged trees growing on bedrock or thin soil.

Ledges and cracks along the cliff face support sparse vegetation with occasional stunted trees and shrubs including northern white-cedar (*Thuja occidentalis*), paper birch, red pine, choke cherry, and serviceberries, and scattered clumps of low shrubs such as bearberry, common juniper, bush honeysuckle, and raspberries (*Rubus* spp.). Ferns are prevalent along the moist ledges and protected fissures and include common polypody (*Polypodium virginianum*), smooth cliff brake (*Pellaea glabella*), maidenhair spleenwort (*Asplenium trichomanes*), and rusty woodsia (*Woodsia ilvensis*). Characteristic herbaceous species include wild columbine (*Aquilegia canadensis*), wild strawberry (*Fragaria virginiana*), rock whitlow-grass (*Draba arabisans*, state special concern), and downy Solomon seal (*Polygonatum pubescens*).

Areas of talus slope, concentrated at the base of the cliff, are characterized by sparse vegetation as well with scattered and stunted trees and tall shrubs including northern white-cedar, paper birch, white pine, white spruce (*Picea glauca*), balsam fir (*Abies balsamea*), quaking aspen (*Populus tremuloides*), choke cherry, and serviceberries. The low shrub layer is often the most dense stratum in this zone, particularly in areas of high slope near the base of the cliff face. Dominant species of the low shrub layer and ground cover include stunted choke cherry, bush honeysuckle, thimbleberry (*Rubus parviflorus*), poison ivy (*Toxicodendron radicans*), and common polypody. Areas of extensive or recent rock slide are often devoid of vegetation except for lichens encrusted on boulders.

Noteworthy Animals

Cliffs provide nesting habitat for raptors and common ravens (*Corvus corax*).

Rare Plants

Dryopteris filix-mas (male fern, state special concern)

Dryopteris fragrans (fragrant cliff woodfern, state special concern)

Gymnocarpium jessoense (limestone oak fern, state special concern)

Huperzia appalachiana (mountain fir-moss, state special concern)

Pterospora andromedea (pine-drops, state threatened)

Rare Animals

Falco columbarius (merlin, state threatened)

Falco peregrinus (peregrine falcon, state endangered)

Haliaeetus leucocephalus (bald eagle, state special concern)

Biodiversity Management Considerations

Threats to cliffs include logging of adjacent uplands and associated soil erosion, excessive foot traffic along the upper edge, rock climbing, and invasive plants. The thin soils and unstable environment make soil development and plant reestablishment slow, highlighting the importance of minimizing logging and excessive trampling along the upper edge of cliffs. Maintaining a mature, unfragmented forested buffer around granite cliff may help limit the local seed source for invasive species distributed by wind or birds. Some of the invasive plants that may threaten the biodiversity of granite cliffs include spotted knapweed (*Centaurea maculosa*), ox-eye daisy (*Chrysanthemum leucanthemum*), Canada bluegrass (*Poa compressa*), Kentucky bluegrass (*P. pratensis*), sheep sorrel (*Rumex acetosella*), and hawkweeds (*Hieracium* spp.). Monitoring and control efforts to detect and remove these and other invasive species will help maintain the ecological integrity of granite cliff and surrounding natural communities.

Variation

Several types of bedrock are included within this plant community in Michigan, including granite, gneiss, quartzite, and probably several other types of metamorphic rock.

Similar Natural Communities

Volcanic cliff, limestone cliff, sandstone cliff, granite lakeshore cliff, volcanic lakeshore cliff, sandstone lakeshore cliff, limestone lakeshore cliff, granite bedrock glade, volcanic bedrock glade, and northern bald.

Relevant Literature

- Albert, D.A., P. Comer, D. Cuthrell, D. Hyde, W. MacKinnon, M. Penskar, and M. Rabe. 1997. The Great Lakes bedrock lakeshores of Michigan. Michigan Natural Features Inventory, Lansing, MI. 218 pp.
- Dorr, J.A., Jr., and D.F. Eschman. 1970. Geology of Michigan. University of Michigan Press, Ann Arbor, MI. 470 pp.
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- LaBerge, G.L. 1994. Geology of the Lake Superior region. Geoscience Press, Phoenix, AZ. 313 pp.
- Reed, R.C., and J. Daniels. 1987. Bedrock geology of northern Michigan. State of Michigan Department of Natural Resources. Map: 1: 500,000.

Volcanic Cliff

Global/State Rank: G4G5/S2

Overview

Volcanic cliffs consist of vertical or near-vertical exposures of bedrock, which support less than 25% vascular plant coverage, although lichens, mosses, and liverworts are abundant on some rock surfaces. The cliffs can be as high as 80 m (260 ft) and occur on inland exposures of the resistant Middle Keweenaw volcanic rock, which runs from the north tip of the Keweenaw Peninsula south into Wisconsin and also along the entire length of Isle Royale.

Landscape Context

The bedrock of the Keweenaw Peninsula dips steeply toward the north and into Lake Superior, while the south face of the bedrock forms cliffs. The cliffs vary from only a few meters high to over 80 m (260 ft) high. On the Keweenaw Peninsula, most of the cliffs are formed of massive basalt, but there are also some areas of cliff composed of volcanic conglomerate rock. Some of the highest and most extensive cliffs are associated with the Greenstone Flow, part of the Portage Lake Volcanics. Cliffs of the Greenstone Flow can be seen in Keweenaw County along US Highway 41, from the towns of Allouez and Ahmeek in the south to the towns of Delaware and Mandan in the north. The Greenstone Flow also forms inland cliffs parallel to the south shore of Isle Royale. Other large expanses of cliff are associated with the resistant Copper Harbor Conglomerate, of which some of the best known sites are Brockway and Lookout Mountains. Other large cliffs are associated with the interface of the Portage Lake Volcanics and the Jacobsville Sandstones, as seen at Mt. Bohemia.

Volcanic cliff also occurs in Ontario, Wisconsin, and Minnesota. In Michigan, volcanic cliff is typically bordered by boreal forest and occasionally by dry-mesic northern forest, mesic northern forest, or volcanic bedrock glade.

Soils

There is little soil development on the steep rock face of the cliffs. Some organic soil development occurs in crevices in the rock face, on the upper lip of the cliffs, and at the base of the cliff face.

Natural Processes

The combination of vertical exposure, thin soils, strong winds, and ice maintain open conditions on the cliff face. The cliffs are exposed to extreme storm winds, often from Lake Superior. Storm winds uproot trees and erode soils. Windblown trees at the base of the cliff provide localized areas for soil accumulation. Thin soils, winter winds, full exposure, and summer droughts produce a desiccating environment for plants. The regularly occurring fog from nearby Lake Superior may partially mitigate these desiccating effects during the growing season.

Vegetation

While mosses and lichens are common on the exposed cliff face, vascular plant cover is sparse, being generally restricted to the flat, exposed bedrock at the upper edge of the cliff (i.e., lip), cracks and joints in the cliff face, and along the cliff base, where a talus slope typically develops. The upper edge of the cliff is typically backed by boreal forest, dry-mesic northern forest, or mesic northern forest, with abundant windthrown trees resulting from strong winds. Herbaceous species characteristic of the upper flat edge or lip include harebell (*Campanula rotundifolia*),

balsam ragwort (*Senecio pauperculus*), wild strawberry (*Fragaria virginiana*), early saxifrage (*Saxifraga virginiana*), yarrow (*Achillea millefolium*), hair grass (*Deschampsia cespitosa*), and the invasive species Canada bluegrass (*Poa compressa*). Shrubs occurring along the upper lip include soapberry (*Shepherdia canadensis*), serviceberries (*Amelanchier* spp.), and wild rose (*Rosa acicularis*). Some of the few plants that occur on the cliff face are occasional patches of common polypody (*Polypodium virginianum*), harebell, and hair grass. Shrub-sized red oak (*Quercus rubra*) and paper birch (*Betula papyrifera*) occur on the summits of some of the inland cliffs. Their dwarf size is the result of strong winds and ice storms.

Noteworthy Animals

Cliffs provide nesting habitat for raptors and common raven (*Corvus corax*).

Rare Plants

Ceanothus sanguineus (wild-lilac, state threatened)
Chamaerhodos nuttallii var. *keweenawensis* (Keweenaw rock-rose, state endangered)
Collinsia parviflora (small blue-eyed Mary, state threatened)
Danthonia intermedia (wild oat-grass, state special concern)
Draba arabisans (rock whitlow-grass, state special concern)
Draba cana (ashy whitlow-grass, state threatened)
Muhlenbergia cuspidata (plains muhly, presumed extirpated from Michigan)
Pellaea atropurpurea (purple cliff-brake, state special concern)
Poa canbyi (Canby's bluegrass, state threatened)
Saxifraga paniculata (encrusted saxifrage, state threatened)
Senecio indecorus (rayless mountain ragwort, state threatened)
Trisetum spicatum (downy oat-grass, state special concern)
Woodsia alpina (northern woodsia, state endangered)
Woodsia obtusa (blunt-lobed woodsia, state threatened)

Rare Animals

Falco columbarius (merlin, state threatened)
Falco peregrinus (Peregrine falcon, state endangered)
Haliaeetus leucocephalus (bald eagle, state special concern)
Planogyra asteriscus (eastern flat-whorl, state special concern)
Vertigo bollesiana (delicate vertigo, state threatened)
Vertigo cristata (land snail, state special concern)
Vertigo modesta modesta (land snail, endangered)
Vertigo modesta parietalis (land snail, endangered)
Vertigo paradoxa (land snail, state special concern)

Biodiversity Management Considerations

Threats to volcanic cliffs include development, logging of adjacent uplands and associated soil erosion, excessive foot traffic along the upper edge, and invasive plants. The thin soils and unstable environment make soil development and plant reestablishment slow, highlighting the importance of minimizing logging and excessive trampling along the upper edge of cliffs. Maintaining a mature, unfragmented forested buffer around volcanic cliff may help limit the local seed source for invasive species distributed by wind or birds. Some of the invasive plants that may threaten the diversity and structure of volcanic cliffs include spotted knapweed (*Centaurea maculosa*), ox-eye daisy (*Chrysanthemum leucanthemum*), Canada bluegrass (*Poa compressa*), Kentucky bluegrass (*P. pratensis*), sheep sorrel (*Rumex acetosella*), and hawkweeds (*Hieracium* spp.). Monitoring and control efforts to detect and remove these and other invasive species will help maintain the ecological integrity of volcanic cliff and surrounding natural communities.

Variation

Cliffs occur on both volcanic conglomerate and massive basalt. Vegetation diversity appears to be higher on the conglomerate substrate.

Similar Natural Communities

Granite cliff, limestone cliff, sandstone cliff, granite bedrock glade, volcanic bedrock glade, volcanic lakeshore cliff, and northern bald.

Relevant Literature

- Albert, D.A., P. Comer, D. Cuthrell, D. Hyde, W. MacKinnon, M. Penskar, and M. Rabe. 1997. The Great Lakes bedrock lakeshores of Michigan. Michigan Natural Features Inventory, Lansing, MI. 218 pp.
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SUBTERRANEAN/SINK COMMUNITIES

Cave

Global/State Rank: G4?/S1

Overview

A cave is defined as a cavity beneath the earth's surface, often with an opening to the surface, characterized by little or no light, no primary producers, and biotic communities of one or two trophic levels that import energy from outside the system. Caves are known from the eastern Upper Peninsula, and historically, from southeast Lower Michigan.

Landscape Context

All of Michigan's caves occur in karst landscapes, where dissolution of limestone or dolomite creates an underground drainage system that can include caves. Michigan's areas of true karst are limited in extent, but include considerable variety. The Michigan Karst Conservancy owns the 480 acre Fiborn Karst Preserve in Michigan's Upper Peninsula, which includes an extensive and nearly complete karst drainage system with sinkholes, caves, and disappearing streams.

Soils

There is no information on soil development within Michigan's caves, but since they are derived from limestone or dolomite, soils are likely mildly to moderately alkaline.

Natural Processes

Caves form from the dissolution of limestone, dolomite, or gypsum. The dissolution of the bedrock, often along faults or cracks in the bedrock, results in the creation of an underground drainage system rather than typical surface streams. Some caves collapse, forming sinkholes.

Vegetation

It is assumed that there is no vegetation within Michigan's caves.

Noteworthy Animals

Caves provide habitat and hibernacula for bats. A small cave in Monroe County, now destroyed, was rumored to have a population of blind crayfish. Little is known about the biology of Michigan's remaining caves, but contrary to the situation in better-known caves of other states, no evidence exists that unusual organisms or groupings of organisms make their homes in them.

Rare Plants

None documented.

Rare Animals

None documented.

Biodiversity Management Considerations

In the Upper Peninsula, one large and several small caves have been quarried away. Small caves in Monroe County have also been destroyed. Erosion damage can occur due to uncontrolled foot traffic. Maintaining a forested buffer around caves will help prevent soil erosion and associated runoff into caves.

Variation

Caves form from the dissolution of several rock types including limestone, dolomite, and gypsum, which differ in their chemical composition and rates of erosion, and influence cave size and structure.

Similar Natural Communities

Sinkhole.

Relevant Literature

Dorr, J.A., Jr., and D.F. Eschman. 1970. *Geology of Michigan*. University of Michigan Press, Ann Arbor, MI. 470 pp.

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Michigan Karst Conservancy.

http://www.caves.org/conservancy/mkc/michigan_karst_conservancy.htm.

Sinkhole

Global/State Rank: G3G5/S2

Overview

Sinkholes are depressions in the landscape caused by the dissolution and collapse of subsurface limestone, dolomite, or gypsum. The term *karst*, first applied to a plateau region of the Dinaric Alps in Yugoslavia, is now used to describe regions throughout the world that have features formed largely by underground drainage. Karst terrains are characterized by caves, steep valleys, sinkholes, and a general lack of surface streams. Sinkholes are found predominantly in the northeastern Lower Peninsula and eastern Upper Peninsula.

Landscape Context

Michigan's areas of true karst are limited in extent, but include considerable variety. The most extensive area of sinkholes and earth cracks is found in Alpena and Presque Isle Counties. A broad band of outcrops of the Niagara Escarpment in the Upper Peninsula contains numerous karst sinks, springs, and caves. Gypsum karst is found in Kent and Iosco Counties; a significant amount of surface drainage goes underground in Monroe County, reappearing as "blue holes" in Lake Erie. In addition, numerous sinkhole lakes occur within Otsego and Montmorency Counties. The surrounding landscape typically supports mesic northern forest, boreal forest, limestone bedrock glade, and alvar in the uplands and groundwater-fed wetland systems such as northern fen, poor fen, intermittent wetland, and rich conifer swamp in the lowlands. Where deep outwash sands overlay sinkholes, drier upland types may occur including dry-mesic northern forest and dry northern forest.

Soils

The soils within most of Michigan's karst features are derived from limestone or dolomite, and are thus mildly to moderately alkaline and fine-textured. Some of the sinkholes in Montmorency, Otsego, and Presque Isle Counties are overlain by outwash sands and support vegetation characteristic of acid sands – no bedrock is exposed in these sinkholes.

Natural Processes

Karst forms a dynamic, ever-changing landscape resulting from the dissolution of limestone, dolomite, or gypsum. The dissolution of the bedrock, often along faults or cracks in the bedrock, results in the creation of an underground drainage system rather than typical surface streams. As the dissolution of the underlying bedrock continues, it collapses in some locations and forms sinkholes, some of which seasonally or permanently flood to form lakes or ponds. Some underground streams of the karst regions reemerge as springs, sometimes off shore in Lake Michigan or Lake Huron. Coarse woody debris loads from surrounding uplands provide important structural features within sinkholes. Recently formed sinkholes are often covered by fallen logs.

Vegetation

Although the vegetation is predominantly that of the surrounding forest, moister and cooler conditions may provide habitat for ferns, mosses, and lichens not typically found in the area of the sinkhole. Vertical limestone walls are often exposed along the margins of sinkholes and provide habitat for species characteristic of limestone cliffs. Where exposures of limestone are prevalent, sinkholes support a diversity of mosses, lichens, liverworts, and ferns. Where sinkhole ponds or lakes develop, emergent marsh often rings the shore of the water. However, the flora of

Michigan's karst is much less diverse than karst floras in the southeastern U.S., where rare plant diversity is often high.

Noteworthy Animals

Both sinkholes and caves provide habitat and hibernacula for bats.

Rare Plants

Asplenium rhizophyllum (walking fern, state threatened)

Dryopteris filix-mas (male fern, state special concern)

Rare Animals

None documented.

Biodiversity Management Considerations

Indiscriminate use of sinkholes in Alpena County as dumps and landfills still occurs, which results in groundwater pollution and degrades and obscures these fascinating features. Many sinkholes have also been filled in for farming. In some areas, erosion damage is occurring due to uncontrolled foot and vehicle traffic. Where sinkholes occur within forested systems, maintaining a mature, unfragmented buffer around their perimeters will help reduce soil erosion and runoff into sinkholes and may help limit the local seed source for invasive species distributed by wind or birds. Monitoring and control efforts to detect and remove invasive species will help maintain the ecological integrity of sinkholes and surrounding natural communities. Invasive species that may threaten the diversity and community structure of sinkholes include glossy buckthorn (*Rhamnus frangula*), common buckthorn (*R. cathartica*), Eurasian honeysuckles (*Lonicera maackii*, *L. Morrowii*, *L. tatarica*, and *L. xbella.*), Japanese barberry (*Berberis thunbergii*), multiflora rose (*Rosa multiflora*), autumn olive (*Elaeagnus umbellata*), European highbush cranberry (*Viburnum opulus*), and Norway maple (*Acer platanoides*).

Variation

Karst occurs in a variety of rock types in Michigan, including limestone, dolomite, and gypsum. To date, plant inventories have been focused on the limestone and dolomite karst, but insufficient data has been collected to determine whether there are floristic differences among these bedrock types.

Similar Natural Communities

Cave.

Relevant Literature

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Michigan Karst Conservancy.

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