LANDFIRE Biophysical Setting Model

Biophysical Setting 5013021 Laurentian-Acadian Northern Hardwoods Forest

☐ *This BPS is lumped with:*

☑ *This BPS is split into multiple models:* *This model was split into 13021 (original 1302 concept) and 13022 (hemlock-hardwoods concept) during review of MZ50's BpS layer. Hemlock is minor in 13021 and can occupy >50% of the canopy cover in 13022.*

General Information

Contributors (also see the Comments field **Date** 3/21/2007

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Modeler 2			**Reviewer**	Brendan Ward	bward@fs.fed.us
Modeler 3			**Reviewer**		

Vegetation Type

Forest and Woodland

Map Zone

50

Model Zone

☐ Alaska ☐ N-Cent.Rockies
☐ California ☐ Pacific Northwest
☐ Great Basin ☐ South Central
☑ Great Lakes ☐ Southeast
☐ Northeast ☐ S. Appalachians
☐ Northern Plains ☐ Southwest

Dominant Species*

ACSA3 TSCA
TIAM PRSE2
BEAL2
ULAM

General Model Sources

☑ Literature
☑ Local Data
☑ Expert Estimate

Geographic Range

This system occurs in the western Upper Peninsula of MI, northern WI, northern MN, and Ontario. In MI, it occurs in subsections 212Tb, 212Ya, 212Jb, 212Sq, 212Jo, and 212Sn. In WI this system occurs in all of the 212 subsections.

Biophysical Site Description

For LANDFIRE mapping, SSURGO map units with moderate percentages of silt (20-50%) and low to moderate percentages of sand (<50%) may be helpful for constraining the distribution of this system.

This type occurs principally on moraines of well drained soils that are coarse and fine textured, on lacustrine silts and clays, and on medium-textured till over bedrock -- areas of consistent moisture and nutrient availability that are protected from fire. Soils can frequently exhibit a thicker Bhs horizon and have a higher organic content, cation exchange capacity. Soil pH will range from 6.0 to 7.5. Typical sites are buffered from seasonal drought by fine-textured moisture-retaining soils or dense subsoil layers. Essential nutrients are mineralized from decaying organic matter at twice the rate of that in fire-dependent forest or wet forest communities.

Vegetation Description

This system is a mixture of mesophyllic hardwood species and is typified by Acer saccharum, Tilia americana, Fagus grandifolia (restricted to MZ51 and eastern MZ50), Betula allegheniensis, and Ulmus americana. Populus tremuloides, Populus grandidentata and Betula papyrifera are early seral species in

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this system. Acer rubrum and Abies balsamea occasional species found in mid-seral stands, especially on less productive soils. Occasional Pinus strobus individuals were present in early and mid-seral stands that were in proximity to seed sources, but their presence in contemporary forests likely indicates a site that would have formerly been occupied more strongly by pine under the natural disturbance regime. Tsuga canadensis was an occasional late-seral species, but likely indicates 13022 rather than this BpS.

Structurally, these uneven-aged forests were characterized by large volumes of coarse, structurally complex woody debris arranged both vertically and horizontally beneath multi-storied canopies of different-aged cohorts, with super canopies composed of trees centuries old (Tyrell and Crow 1994). The dominant tree species are among the most moisture and nutrient-demanding species in the eastern US, and their distribution is confined to glacial landforms underlain by fertile soils (Woods 2000, Whitney 1986). Composition of the ground flora and understory varies along a moisture-nutrient gradient, and typically consists of high densities of shade-tolerant tree species and mesophilic herbaceous species including blue cohosh, yellow violet, sweet cicely, various ferns and ginseng. The shrub layer includes Canada yew, beaked hazel, moose wood and Amelanchier species.

In the mid-1800s, there were 5.8 million acres of northern hardwood ecosystems in the Upper Peninsula of Michigan (Cleland 2004a, ongoing R-9/SRS/MTU study). Sugar maple, hemlock, yellow birch, balsam fir, cedar in swales, spruce and beech were the dominant late-successional species recorded along section lines by GLO surveyors. Early-successional aspen and white birch comprised only 20.0% of the GLO line trees. Large openings likely occurred on less than one percent of the landscape.

In the mid-1800's, there were 8.4 million acres of northern hardwood ecosystems within the 17.8 million acres of forest lands in northern Wisconsin (ongoing R-9/SRS/MTU study). Yellow birch, sugar maple, hemlock, white pine, elm and basswood were the dominant late-successional species. Early-successional aspen, white birch and oak species comprised 4.8% of the GLO corner trees. Large openings likely occurred on less than one percent of the landscape.

Disturbance Description

These wind-driven ecosystems historically changed slowly over centuries due to fine-scale blowdowns, relatively rare broad-scale catastrophic storms, and even rarer fire events (Cleland et al. 2004, Woods 2000, Frelich and Lorimer 1991, Canham and Loucks 1984, Grimm 1984, Runkle 1982). Blowdowns affected conifers more than hardwoods, and older trees more than younger trees (Foster and Boose 1992, Webb 1989). These "asbestos" forests seldom burned (Grimm 1984, Stearns 1949), and exhibited a repeating and shifting steady state of fine-scaled mosaics of species whose overall proportions remained essentially constant (Borman and Likens 1979).

Fire Regime Description: Composed of fire-sensitive species, fires only occurred within this forest type following catastrophic wind events or during periods of extreme drought. This fire-resistance is due to high rates of organic matter decomposition and low rates of fuel accumulation, closed and multistoried canopy effects on microclimate, succulent ground-flora and herbaceous layers, high soil moisture storage capacity, and the dispersed canopies of volatile coniferous foliage within a fire-resistant deciduous hardwood matrix. The principal cause of fuel formation leading to fire in northern hardwood ecosystems is broad scale, storm-driven windthrow of catastrophic proportions (Canham and Loucks 1984, Dunn et al. 1983, Runkle 1982). Canham and Loucks (1984) estimated the return interval for catastrophic storms to be about 1200yrs in northern WI. Their comparisons of the presettlement disturbance regime with contemporary climatological records suggest that catastrophic thunderstorms were the principal mechanism for large-scale windthrow, followed by tornadoes that accounted for one-third of blowdown

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recorded by surveyors. Not only were these storms nearly stand-replacing events in themselves, but after the slash resulting from them cured, the probability of fire increased exponentially. However, fires within undisturbed, intact systems that did start or that moved into these stands from adjacent areas tended to smolder in the duff layer and move very slowly, eventually going out and causing little damage to the overstory (Frelich and Lorimer 1991, Stearns 1949).

Within the 5.8 million acres of northern hardwood ecosystems in the Upper Peninsula of MI, there were 146,028ac of blown down forests and 54,903ac of burned areas based on analyses of General Land Office survey notes recorded between 1840 and 1855 (Cleland et al. 2004a, Maclean and Cleland 2003). Assuming a 15yr recognition window, the historical fire rotation was 1568yrs. If surveyors recognized a blow-down 20yrs after the event, catastrophic wind rotations would have been 786yrs, with a 30yr recognition window estimate of 1179yrs. Because of the fire-resistance of undisturbed mesic deciduous forests, these estimates suggest that approximately 40% of the blown-down areas within this forest type in the Upper Peninsula subsequently burned.

Within the 8.4 million acres of northern hardwood ecosystems in northern Wisconsin, there were 396,485ac of blown-down forests and 61,800ac of burned areas based on analyses of General Land Office survey notes recorded between 1840 and 1855 (Cleland et al. 2004a). Assuming a 15yr recognition window, the historical fire rotation was 2039yrs. If surveyors recognized a blow-down 20yrs after the event, catastrophic wind rotations would have been 425yrs, with a 30-year recognition window estimate of 637yrs. Because of the fire-resistance of undisturbed mesic deciduous forests, these estimates suggest that approximately 16% of the blown-down areas in this forest type in Wisconsin subsequently burned. Wisconsin's northern hardwood communities experienced more wind and less fire disturbance than those in MI's Upper Peninsula. Although wind rotations differed across the two-state area, fire rotations for northern hardwoods were uniformly very long, ranging from 1400yrs to more than 2000yrs.

Fire Regime Group V is applicable to this system. Severe wind events were assumed to reset mature stands on an approximate 1100yr rotation in MI's Upper Peninsula in the following VDDT models. Most replacement fire occurs in slash created by these wind events. Forty percent of the blowdown areas burn and revert to an open land or an early-seral aspen-birch stage that lasts 60yrs. Replacement fires without associated wind events are very rare.

Insects and disease are present but in a very minor way most likely affecting individual trees versus at a stand level. As an example root and stem rot cause individual tree mortality primarily in late development. These types of disturbances would likely contribute to higher fuel loads and structural complexity of stands.

Adjacency or Identification Concerns

BpS adjacent to this system include 13022 (Laurentian-Acadian Northern Hardwood Forest - Hemlock), 1310 (North-Central Interior Dry-Mesic Oak Forest and Woodland), 1311 (North-Central Interior Dry Oak Forest and Woodland), 1344 (Boreal Jack Pine-Black Spruce Forest) and 1345 (Boreal White Spruce forest and Woodland).

This system can be easily confused with 1314 (North-Central Interior Maple Basswood Forest) and 1362 (Laurentian-Acadian Northern Pine-Oak Forest).

Exotics and invasives such as earthworms, garlic mustard, European buckthorn and honey suckle occur presently but would not have effected this system historically. Encroachment in the form of conversion, urban sprawl and management practices (forestry and fire suppression) are effects that would not have

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impacted this system historically but occur in the present day.

As a result of the forest management practices in the late 1800s the majority of today's forests are second growth. In terms of structure and composition this system is much simpler in present day lacking shrub species such as Canada yew and the successional stages tend to be younger resulting in a second growth forest. The presence of exotics and invasives in the present day forest should also be noted.

It is possible that the replanting efforts by the Civilian Conservation Core (CCC) in the 1930s have converted some of this system to red pine monoculture.

This type is mostly embedded within the Northern Hardwood-Hemlock forest and occurs as small to large patches, associated with Sugar Maple - Hemlock and Sugar Maple - Yellow Birch cover types--the latter being primarily in Subsection 212Jc and 212Xc. The maple-basswood forest type is usually associated with more nutrient-rich and moisture-rich sites.

Native Uncharacteristic Conditions

Scale Description

This type is a large patch or small patch system within the dominant BpS, Northern Hardwood - Hemlock, across northern MN, northern WI and the western Upper Peninsula of MI.

Issues/Problems

In the course-scale assessment, this type was called Northern Hardwoods (#51). Kuchler (1964) typed the WI portion as Northern Hardwoods, but the UP portion as Northern Hardwood-Fir. We based this description on the FRCC Northern Hardwood-Fir description document.

The 13020 model developed by Peggy Burkman on 3/21/2007 was split into 13021 (original model) and 13022 (hemlock-hardwoods) by Brendan Ward on 10/24/2007. The VDDT models are identical between the split models, and only minor descriptive changes were made to 13021 and 13022 to reflect this split.

Comments

Following the model evolution notes are comments from a reviewer; many of these comments were not incorporated into the VDDT model because of lack of consent from original modeler (Randy Swaty contacted modeler who was unable to review comments by deadline. See below). However, comments noting inconsistencies between the MTDB and VDDT databases were incorporated, and math errors with draft models fixed.

During the S-classing process we received the following comments from David Mladenoff:
1. Much of the literature is from areas outside of this map zone-disturbance regimes from other parts of the country could be significantly different than in MZ50.
2. The more moderate class of disturbances is not accounted for in the model. In these systems small windthrow can be a primary disturbance. If these disturbances were added it was hypothesized that there would be 5-10% more in the mid-successional classes.

This model is adapted from LANDFIRE Model 511302-3 Northern Sugar-Maple-Basswood Forest by Doug Pearsall (dpearsall@tnc.org) and Brad Slaughter (slaughterb@michigan.gov). Model 511302-3 was based on Rapid Assessment Model created by Cleland, Merzenich and Parker for biophysical setting R6NHHEgl, "Northern Hardwood-Hemlock Forest (Great Lakes)". The LANDFIRE Model 511302-3 also used Rapid Assessment Model R6MBMHW as a basis for much of its characterization. In the MZ51

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assessment, we are considering this type to be a large-patch system within a matrix of hemlock-northern hardwoods.

Comments from Rapid Assessment: In the course-scale assessment, this type was called Northern Hardwoods (#51). Kuchler typed the Wisconsin portion as Northern Hardwoods, but the UP portion as Northern Hardwood-Fir. We based this description on the FRCC Northern Hardwood-Fir description document. At the Great Lakes Rapid Assessment workshop it was agreed to rename as Northern Hardwood-Hemlock Forest (Great Lakes). Suggested reviewers: Eric Epstein (WDNR Natural Heritage Ecologist, Randy Hoffman (WDNR Natural Areas program), Eunice Padley (WDNR Div of Forestry), Mike Kost (Mich NFI), John Almendinger (MN DNR).

Need review from MI experts to include occurrence of this BpS in MZ41. Suggested reviewers are Dave Cleland and Paul Tine.

AFOREMENTIONED COMMENTS FROM REVIEWER:

Reviewer suggests that the disturbances should be modeled somewhat differently to get at the causal mechanism (coupled windthrow and fire) a little bit cleaner than how they are modeled (high fire frequency in class A, which doesn't make ecological sense because it is post-fire). Reviewer suggests that the fire probabilities in D should reflect the coupling of these two disturbances, since otherwise it would be very rare (e.g, the specified 5000yr interval). Reviewer would work it out this way – the goal being a wind interval without subsequent fire of about 1000yrs (as modeled for D). Thus if somewhere around 40% of windthrow events resulted in fire (as described in model), we solve for a total wind return interval of 600yrs (p=0.00166), and a wind followed by fire rate of 1500yrs (p=0.00066). A more conservative estimate of 33% of windthrow followed by fire would be a 2000yr MFRI (p=0.0005), which fits fairly well with the disturbance description. The reviewer suggests that either of these is a high enough rate to include the very rare fires without previous windthrow as well, so this can become the fire probability for D, and therefore suggests opting for the more conservative estimate. In the descriptions, note that the replacement fire (especially in D) represents a coupled wind and fire event and includes the rare fire events without previous wind.
All classes (even A) can experience catastrophic windthrow due to rare downburst / tornado events, but the rate increases toward D because of increasing susceptibility. Decaying aspen stands have a fairly high susceptibility to windthrow too (this starts occurring toward the end of A).

Structural changes to model:
Succession transition from E should go to C rather than itself. There is too much piling up in E, which is contradictory to the vegetation description for this model. I'd call this a fairly serious problem. Around 75% of this system should be in D.

Reassign fire and wind probabilities as follows:
A: Fire (to A): 0.0003; Wind (to B): 0.0004
B: Fire (to A): 0.0003; Wind (to B, but can't change relative age due to modeling rules): 0.0004
C: Fire (to A): 0.0004; Wind (to B): 0.0004
D: Fire (to A): 0.0005; Wind (to B): 0.001
E: Fire (to A): 0.0004; Wind (to B): 0.001

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Final Percents:
A: 2
B: 4
C: 15
D: 78
E: 1
MFRI: 2000 (this is in line with disturbance description)

Classes:
SClass A:
Add Populus grandidentata (POGR4) to the species list. Reviewer has some agreement with where the high fire probabilities come from in this class, since they are intended to represent the post-windthrow fire probabilities. However, the post-fire probabilities in aspen/birch are in reality low as far as the reviewer is concerned, and there is no probability of fire in 1301 class A as modeled; this creates some logic problems.

SClass B:
Replace POTR5 in species list with BEPA, which can capitalize on windthrow openings / gaps better than aspen which is much happier post-fire.

Vegetation Classes

Class A 2 %

Early Development 1 All Structure

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

POTR5	Upper
BEPA	Upper

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	100 %
Height	Tree 0m	Tree 5m
Tree Size Class	Pole 5-9" DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Class A contains early-seral stands characterized by aspen and paper birch 0-39yrs of age. It occurs due to the combination of blowdown followed by fire. Forty percent of blowdown areas burn and revert to this class.

This class will succeed to E. Replacement fire, modeled with the probability of occurring every 400yrs (0.0025), will maintain the system in this class.

Class B 4 %

Early Development 2 All Structure

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

ACSA3	Upper
TIAM	Upper
BEAL2	Upper
POTR5	Upper

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	100 %
Height	Tree 5.1m	Tree 10m
Tree Size Class	Pole 5-9" DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

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Class B contains regenerating stands 0-39yrs of age dominated by mid-tolerant northern hardwood species. Windthrow of mature stands (without subsequent fire) generally results in this class. Includes a combination of new recruits and sprouts.

Class B succeeds to C. Replacement fire, modeled with the probability of occurring every 4000yrs (0.0003), will return the system to class A.

Class C **14 %**

Mid Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

ACSA3	Upper
TIAM	Upper
BEAL2	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	81 %	100 %
Height	Tree 10.1m	Tree 25m
Tree Size Class	Medium 9-21"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Maximum height can exceed 25m, but will not reach 50m.

Description

Class C contains mid-aged stands 40-150yrs of age dominated by sugar maple and basswood. The susceptibility to windthrow increases after age 75yrs, modeled as wind/weather/stress on 1000yr basis. Windthrow will return this system to class B. Replacement fire, modeled with the probability of occurring on a 4000yr basis (0.0003) would return this system to class A. This class succeeds to class D.

Class D **76 %**

Late Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

ACSA3	Upper
TIAM	Upper
BEAL2	Upper
TSCA	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	81 %	100 %
Height	Tree 25.1m	Tree 50m
Tree Size Class	Very Large >33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Class D represents old late-seral forests and the end point of succession. These stands are greater than 150yrs old. Sugar maple and basswood are co-dominants, with occasional yellow birch, American elm, white ash and hemlock.

Windthrow modeled as wind/weather/stress on 1000yr basis (0.001) will return this system to class B. Replacement fire, modeled with the probability of occurring on a 2000yr basis (0.0005) would return this system to class A.

Class E **4 %**

Mid Development 2 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

POTR5	Upper
ACSA3	Mid-Upper
TIAM	Mid-Upper
BEPA	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	61 %	80 %
Height	Tree 10.1m	Tree 25m
Tree Size Class	Medium 9-21"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

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Description

Class E represents transition from fire response, early successional stands (class A) to mid-successional maple-basswood stands (class C). Stand age is from 40-89yrs.

Windthrow modeled as wind/weather/stress on 1000yr basis (0.001) will return this system to class B. Replacement fire, modeled with the probability of occurring on a 6000yr basis (0.0006) would return this system to class A.

Disturbances

Fire Regime Group:** V

Historical Fire Size (acres)

Avg 500
Min
Max

Sources of Fire Regime Data

- [x] Literature
- [x] Local Data
- [x] Expert Estimate

Fire Intervals	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	2000			0.0005	96
Mixed					
Surface					
All Fires	1992			0.00052	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fir combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inver of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- [ ] Insects/Disease
- [x] Wind/Weather/Stress
- [ ] Native Grazing
- [ ] Competition
- [ ] Other (optional 1)
- [ ] Other (optional 2)

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LANDFIRE Biophysical Setting Model

***Biophysical Setting* 5013022** **Laurentian-Acadian Northern Hardwoods Forest - Hemlock**

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☑ *This BPS is split into multiple models: This model was split into 13021 (original 1302 concept) and 13022 (hemlock-hardwoods concept) during review of MZ50s BpS layer. Hemlock is minor in 13021 and can occupy >50% of the canopy cover in 13022.*

General Information

Contributors (also see the Comments field **Date** 10/24/2007

Modeler 1	Dave Cleland	dcleland@fs.fed.us	**Reviewer**
Modeler 2	Brendan C Ward	bward@fs.fed.us	**Reviewer**
Modeler 3			**Reviewer**

Vegetation Type

Forest and Woodland

Map Zone

50

Model Zone

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☐ California ☐ Pacific Northwest
☐ Great Basin ☐ South Central
☑ Great Lakes ☐ Southeast
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☐ Northern Plains ☐ Southwest

Dominant Species*

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General Model Sources

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Biophysical Site Description

For LANDFIRE mapping, SSURGO map units with moderate percentages of silt (20-50%) and low to moderate percentages of sand (<50%) may be helpful for constraining the distribution of this system.

This type occurs principally on moraines of well drained soils that are coarse and fine textured, on lacustrine silts and clays, and on medium-textured till over bedrock -- areas of consistent moisture and nutrient availability that are protected from fire. Soils can frequently exhibit a thicker Bhs horizon and have a higher organic content, cation exchange capacity. Soil pH will range from 6 to 7.5. Typical sites are buffered from seasonal drought by fine-textured moisture-retaining soils or dense subsoil layers. Essential nutrients are mineralized from decaying organic matter at twice the rate of that in fire-dependent forest or wet forest communities. Extreme podzolization can occur in relatively pure hemlock stands due to
highly acidic hemlock needles (Curtis 1959).

Vegetation Description

This system is a mixture of mesophyllic hardwood species and hemlock and is typified by Tsuga canadensis, Acer saccharum, Tilia americana, Fagus grandifolia (restricted to MZ51 and eastern MZ50), Betula allegheniensis and Ulmus americana. Populus tremuloides, Populus grandidentata and Betula

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papyrifera are early seral species in this system. Acer rubrum and Abies balsamea occasional species found in mid-seral stands, especially on less productive soils. Occasional Pinus strobus individuals were present in early and mid-seral stands that were in proximity to seed sources, but their presence in contemporary forests likely indicates a site that would have formerly been occupied more strongly by pine under the natural disturbance regime.

Structurally, these uneven-aged forests were characterized by large volumes of coarse, structurally complex woody debris arranged both vertically and horizontally beneath multi-storied canopies of different-aged cohorts, with super canopies composed of trees centuries old (Tyrell and Crow 1994). The dominant tree species are among the most moisture and nutrient-demanding species in the eastern U.S.A., and their distribution is
confined to glacial landforms underlain by fertile soils (Woods 2000, Whitney 1986). Composition of the ground flora and understory varies along a moisture-nutrient gradient, and typically consists of high densities of shade-tolerant tree species and mesophilic herbaceous species including blue cohosh, yellow violet, sweet cicely, various ferns, and ginseng. The shrub layer includes Canada Yew, Beaked Hazel, Moose Wood and Amelanchier species.

In the mid-1800's, there were 5.8 million acres of northern hardwood ecosystems in the Upper Peninsula of Michigan (Cleland 2004a, ongoing R-9/SRS/MTU study). Sugar maple, hemlock, yellow birch, balsam fir, cedar in swales, spruce, and beech were the dominant late-successional species recorded along section lines by GLO surveyors (figure 1). Early-successional aspen and white birch comprised only 20.0% of the GLO line trees. Large openings likely occurred on less than one percent of the landscape.

In the mid-1800s, there were 8.4 million acres of northern hardwood ecosystems within the 17.8 million acres of forest lands in northern WI (ongoing R-9/SRS/MTU study). Yellow birch, sugar maple, hemlock, white pine, elm and basswood were the dominant late-successional species (figure 2). Early-successional aspen, white birch and oak species comprised 4.8% of the GLO corner trees. Large openings likely occurred on less than one percent of the landscape.

Disturbance Description

These wind-driven ecosystems historically changed slowly over centuries due to fine-scale blowdowns, relatively rare broad-scale catastrophic storms, and even rarer fire events (Cleland et al. 2004, Woods 2000, Frelich and Lorimer 1991, Canham and Loucks 1984, Grimm 1984, Runkle 1982). Blowdowns affected conifers more than hardwoods, and older trees more than younger trees (Foster and Boose 1992, Webb 1989). These "asbestos" forests seldom burned (Grimm 1984, Stearns 1949), and exhibited a repeating and shifting steady state of fine-scaled mosaics of species whose overall proportions remained essentially constant (Borman and Likens 1979).

Fire Regime Description: Composed of fire-sensitive species, fires only occurred within this forest type following catastrophic wind events or during periods of extreme drought. This fire-resistance is due to high rates of organic matter decomposition and low rates of fuel accumulation, closed and multistoried canopy effects on microclimate, succulent ground-flora and herbaceous layers, high soil moisture storage capacity, and the dispersed canopies of volatile coniferous foliage within a fire-resistant deciduous hardwood matrix. The principal cause of fuel formation leading to fire in northern hardwood ecosystems is broad scale, storm-driven windthrow of catastrophic proportions (Canham and Loucks 1984, Dunn et al. 1983, Runkle 1982). Canham and Loucks (1984) estimated the return interval for catastrophic storms to be about 1200yrs in northern Wisconsin. Their comparisons of the presettlement disturbance regime with contemporary climatological records suggest that catastrophic thunderstorms were the principal

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mechanism for large-scale windthrow, followed by tornadoes that accounted for one-third of blowdown recorded by surveyors. Not only were these storms nearly stand-replacing events in themselves, but after the slash resulting from them cured, the probability of fire increased exponentially. However, fires within undisturbed, intact systems that did start or that moved into these stands from adjacent areas tended to smolder in the duff layer and move very slowly, eventually going out and causing little damage to the overstory (Frelich and Lorimer 1991, Stearns 1949).

Within the 5.8 million acres of northern hardwood ecosystems in the Upper Peninsula of Michigan, there were 146,028ac of blown down forests and 54,903ac of burned areas based on analyses of General Land Office survey notes recorded between 1840 and 1855 (Cleland et al. 2004a, Maclean and Cleland 2003). Assuming a 15yr recognition window, the historical fire rotation was 1568yrs. If surveyors recognized a blow-down 20yrs after the event, catastrophic wind rotations would have been 786yrs, with a 30yr recognition window estimate of 1179yrs. Because of the fire-resistance of undisturbed mesic deciduous forests, these estimates suggest that approximately 40% of the blown-down areas within this forest type in the Upper Peninsula subsequently burned.

Within the 8.4 million acres of northern hardwood ecosystems in northern Wisconsin, there were 396,485ac of blown-down forests and 61,800ac of burned areas based on analyses of General Land Office survey notes recorded between 1840 and 1855 (Cleland et al. 2004a). Assuming a 15yr recognition window, the historical fire rotation was 2039yrs. If surveyors recognized a blow-down 20yrs after the event, catastrophic wind rotations would have been 425yrs, with a 30yr recognition window estimate of 637yrs. Because of the fire-resistance of undisturbed mesic deciduous forests, these estimates suggest that approximately 16% of the blown-down areas in this forest type in WI subsequently burned. WI's northern hardwood communities experienced more wind and less fire disturbance than those in MI's Upper Peninsula. Although wind rotations differed across the two-state area, fire rotations for northern hardwoods were uniformly very long, ranging from 1400yrs to more than 2000yrs.

Fire Regime Group V is applicable to this system. Severe wind events were assumed to reset mature stands on an approximate 1100-year rotation in MI's Upper Peninsula in the following VDDT models. Most replacement fire occurs in slash created by these wind events. Forty percent of the blowdown areas burn and revert to an open land or an early-seral aspen-birch stage that lasts 60yrs. Replacement fires without associated wind events are very rare.

Insects and disease are present but in a very minor way most likely affecting individual trees versus at a stand level. As an example root and stem rot cause individual tree mortality primarily in late development. These types of disturbances would likely contribute to higher fuel loads and structural complexity of stands.

Adjacency or Identification Concerns

BpS adjacent to this system include 13021 (Laurentian-Acadian Northern Hardwood Forest), 1310 (North-Central Interior Dry-Mesic Oak Forest and Woodland), 1311 (North-Central Interior Dry Oak Forest and Woodland), 1344 (Boreal Jack Pine-Black Spruce Forest) and 1345 (Boreal White Spruce forest and Woodland).

This system can be easily confused with 1314 (North-Central Interior Maple Basswood Forest) and 1362 (Laurentian-Acadian Northern Pine-(Oak) Forest.

Exotics and invasives such as earthworms, garlic mustard, European buckthorn and honey suckle occur presently but would not have effected this system historically. Encroachment in the form of conversion,

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urban sprawl and management practices (forestry and fire suppression) are effects that would not have impacted this system historically but occur in the present day.

As a result of the forest management practices in the late 1800s the majority of today's forests are second growth. In terms of structure and composition this system is much simpler in present day lacking shrub species such as Canada Yew and the successional stages tend to be younger resulting in a second growth forest. The presence of exotics and invasives in the present day forest should also be noted.

It is possible that the replanting efforts by the Civilian Conservation Core (CCC) in the 1930s have converted some of this system to Red Pine monoculture.

This type is mostly embedded within the Northern Hardwood-Hemlock forest and occurs as small to large patches, associated with Sugar Maple - Hemlock and Sugar Maple - Yellow Birch cover types--the latter being primarily in Subsection 212Jc and 212Xc. The maple-basswood forest type is usually associated with more nutrient-rich and moisture-rich sites.

Native Uncharacteristic Conditions

Scale Description

This type is a large patch or small patch system within the dominant BpS, Northern Hardwood - Hemlock, across northern MN, northern WI and the western Upper Peninsula of MI.

Issues/Problems

In the course-scale assessment, this type was called Northern Hardwoods (#51). Kuchler (1964) typed the WI portion as Northern Hardwoods, but the UP portion as Northern Hardwood-Fir. We based this description on the FRCC Northern Hardwood-Fir description document.

The 13020 model developed by Peggy Burkman on 3/21/2007 was split into 13021 (original model) and 13022 (hemlock-hardwoods) by Brendan Ward on 10/24/2007. The VDDT models are identical between the split models, and only minor descriptive changes were made to 13021 and 13022 to reflect this split.

Comments

Following the model evolution notes are comments from a reviewer; many of these comments were not incorporated into the VDDT model because of lack of consent from original modeler (Randy Swaty contacted modeler who was unable to review comments by deadline. See below). However, comments noting inconsistencies between the MTDB and VDDT databases were incorporated, and math errors with draft models fixed.

During the S-classing process we received the following comments from David Mladenoff:
1. Much of the literature is from areas outside of this map zone-disturbance regimes from other parts of the country could be significantly different than in MZ50.
2. The more moderate class of disturbances is not accounted for in the model. In these systems small windthrow can be a primary disturbance. If these disturbances were added it was hypothesized that there would be 5-10% more in the mid-successional classes.

This model is adapted from LANDFIRE Model 511302-3 Northern Sugar-Maple-Basswood Forest by Doug Pearsall (dpearsall@tnc.org) and Brad Slaughter (slaughterb@michigan.gov). Model 511302-3 was based on Rapid Assessment Model created by Cleland, Merzenich and Parker for biophysical setting R6NHHEgl, "Northern Hardwood-Hemlock Forest (Great Lakes)". The LANDFIRE Model 511302-3 also

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used Rapid Assessment Model R6MBMHW as a basis for much of its characterization. In the MZ51 assessment, we are considering this type to be a large-patch system within a matrix of hemlock-northern hardwoods.

Comments from Rapid Assessment: In the course-scale assessment, this type was called Northern Hardwoods (#51). Kuchler typed the Wisconsin portion as Northern Hardwoods, but the UP portion as Northern Hardwood-Fir. We based this description on the FRCC Northern Hardwood-Fir description document. At the Great Lakes Rapid Assessment workshop it was agreed to rename as Northern Hardwood-Hemlock Forest (Great Lakes). Suggested reviewers: Eric Epstein (WDNR Natural Heritage Ecologist, Randy Hoffman (WDNR Natural Areas program), Eunice Padley (WDNR Div of Forestry), Mike Kost (Mich NFI), John Almendinger (MN DNR).

Need review from MI experts to include occurrence of this BpS in MZ41. Suggested reviewers are Dave Cleland and Paul Tine.

AFOREMENTIONED COMMENTS FROM REVIEWER:

Reviewer suggests that the disturbances should be modeled somewhat differently to get at the causal mechanism (coupled windthrow and fire) a little bit cleaner than how they are modeled (high fire frequency in class A, which doesn't make ecological sense because it is post-fire). Reviewer suggests that the fire probabilities in D should reflect the coupling of these two disturbances, since otherwise it would be very rare (e.g, the specified 5000yr interval). Reviewer would work it out this way – the goal being a wind interval without subsequent fire of about 1000yrs (as modeled for D). Thus if somewhere around 40% of windthrow events resulted in fire (as described in model), we solve for a total wind return interval of 600yrs (p=0.00166), and a wind followed by fire rate of 1500yrs (p=0.00066). A more conservative estimate of 33% of windthrow followed by fire would be a 2000yr MFRI (p=0.0005), which fits fairly well with the disturbance description. The reviewer suggests that either of these is a high enough rate to include the very rare fires without previous windthrow as well, so this can become the fire probability for D, and therefore suggests opting for the more conservative estimate. In the descriptions, note that the replacement fire (especially in D) represents a coupled wind and fire event and includes the rare fire events without previous wind.
All classes (even A) can experience catastrophic windthrow due to rare downburst / tornado events, but the rate increases toward D because of increasing susceptibility. Decaying aspen stands have a fairly high susceptibility to windthrow too (this starts occurring toward the end of A).

Structural changes to model:
Succession transition from E should go to C rather than itself. There is too much piling up in E, which is contradictory to the vegetation description for this model. I'd call this a fairly serious problem. Around 75% of this system should be in D.

Reassign fire and wind probabilities as follows:
A: Fire (to A): 0.0003; Wind (to B): 0.0004
B: Fire (to A): 0.0003; Wind (to B, but can't change relative age due to modeling rules): 0.0004
C: Fire (to A): 0.0004; Wind (to B): 0.0004
D: Fire (to A): 0.0005; Wind (to B): 0.001
E: Fire (to A): 0.0004; Wind (to B): 0.001

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Final Percents:
A: 2
B: 4
C: 15
D: 78
E: 1
MFRI: 2000 (this is in line with disturbance description)

Classes:
SClass A:
Add Populus grandidentata (POGR4) to the species list. Reviewer has some agreement with where the high fire probabilities come from in this class, since they are intended to represent the post-windthrow fire probabilities. However, the post-fire probabilities in aspen/birch are in reality low as far as the reviewer is concerned, and there is no probability of fire in 1301 class A as modeled; this creates some logic problems.

SClass B:
Replace POTR5 in species list with BEPA, which can capitalize on windthrow openings / gaps better than aspen which is much happier post-fire.

Vegetation Classes

Class A 2 %

Early Development 1 All Structure

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

POTR5	Upper
BEPA	Upper

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	100 %
Height	Tree 0m	Tree 5m
Tree Size Class	Pole 5-9" DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Class A contains early-seral stands characterized by aspen and paper birch 0-39yrs of age. It occurs due to the combination of blowdown followed by fire. Forty percent of blowdown areas burn and revert to this class.

This class will succeed to E. Replacement fire, modeled with the probability of occurring every 400yrs (0.0025), will maintain the system in this class.

Class B 4 %

Early Development 2 All Structure

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

ACSA3	Upper
TIAM	Upper
BEAL2	Upper
POTR5	Upper

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	100 %
Height	Tree 5.1m	Tree 10m
Tree Size Class	Pole 5-9" DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

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Class B contains regenerating stands 0-39yrs of age dominated by mid-tolerant northern hardwood species. Windthrow of mature stands (without subsequent fire) generally results in this class. Includes a combination of new recruits and sprouts.

Class B succeeds to C. Replacement fire, modeled with the probability of occurring every 4000yrs (0.0003), will return the system to class A.

Class C **14 %**

Mid Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

TSCA	Upper
ACSA3	Upper
BEAL2	Upper
TIAM	

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	81 %	100 %
Height	Tree 10.1m	Tree 25m
Tree Size Class	Medium 9-21"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Maximum height can exceed 25m, but will not reach 50m.

Description

Class C contains mid-aged stands 40-150yrs of age dominated by sugar maple, hemlock, yellow birch and basswood. The susceptibility to windthrow increases after age 75yrs, modeled as wind/weather/stress on 1000yr basis. Windthrow will return this system to class B. Replacement fire, modeled with the probability of occurring on a 4000yr basis (0.0003) would return this system to class A. This class succeeds to class D.

Class D **76 %**

Late Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

TSCA	Upper
ACSA3	Upper
BEAL2	Upper
TIAM	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	81 %	100 %
Height	Tree 25.1m	Tree 50m
Tree Size Class	Very Large >33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Class D represents old late-seral forests and the end point of succession. These stands are greater than 150yrs old. Hemlock can dominate with sugar maple and basswood as co-dominants, with yellow birch, American elm, white ash occasional associates.

Windthrow modeled as wind/weather/stress on 1000yr basis (0.001) will return this system to class B. Replacement fire, modeled with the probability of occurring on a 2000yr basis (0.0005) would return this system to class A.

Class E **4 %**

Mid Development 2 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

POTR5	Upper
ACSA3	Mid-Upper
TIAM	Mid-Upper
BEPA	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	61 %	80 %
Height	Tree 10.1m	Tree 25m
Tree Size Class	Medium 9-21"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

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Description

Class E represents transition from fire response, early successional stands (class A) to mid-successional maple-basswood stands (class C). Stand age is from 40-89yrs.

Windthrow modeled as wind/weather/stress on 1000yr basis (0.001) will return this system to class B. Replacement fire, modeled with the probability of occurring on a 6000yr basis (0.0006) would return this system to class A.

Disturbances

Fire Regime Group:** V

Historical Fire Size (acres)

Avg 500
Min
Max

Sources of Fire Regime Data

- [x] Literature
- [x] Local Data
- [x] Expert Estimate

Fire Intervals	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	2000			0.0005	96
Mixed					
Surface					
All Fires	1992			0.00052	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fir combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inver of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- [ ] Insects/Disease
- [x] Wind/Weather/Stress
- [ ] Native Grazing
- [ ] Competition
- [ ] Other (optional 1)
- [ ] Other (optional 2)

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LANDFIRE Biophysical Setting Model

***Biophysical Setting* 5013100** **North-Central Interior Dry-Mesic Oak Forest and Woodland**

☐ *This BPS is lumped with:*
☐ *This BPS is split into multiple models:*

General Information

Contributors (also see the Comments field **Date** 2/28/2007

Modeler 1	Gregory Nowacki	gnowacki@fs.fed.us	**Reviewer**	Dave Cleland	dcleland@fs.fed.us
Modeler 2			**Reviewer**	Bredan Ward	bward@fs.fed.us
Modeler 3			**Reviewer**		

Vegetation Type
Forest and Woodland

Map Zone
50

Model Zone
☐ Alaska ☐ N-Cent.Rockies
☐ California ☐ Pacific Northwest
☐ Great Basin ☐ South Central
☑ Great Lakes ☐ Southeast
☐ Northeast ☐ S. Appalachians
☐ Northern Plains ☐ Southwest

Dominant Species*
QUAL SAAL5
QUVE QURU
CAGL8 ACRU
CAOV2

General Model Sources
☑ Literature
☑ Local Data
☑ Expert Estimate

Geographic Range
Province 222. For MI 222J. For WI 222K and 222L.

Biophysical Site Description
This system occurs most commonly on interlobates where outwash, ice-contact and end moraine landforms are situated between former glacial lobes. Other landforms suitable for development of the dry-mesic oak forest are sandy ground moraine and lake plains. Common to all these landforms is well-drained, acidic soil characterized by loamy sand and sandy loam. Dry landscape settings, such as on western and southern
aspects and upper slopes and ridge tops are conducive to the development of North-Central Interior Dry Oak Forest and oodland (1311) or North-Central Interior Oak Savanna (1394) rather than this system (Curtis 1959). Eastern and northern slopes with sufficient fire frequency to minimize the mesophytic species are more conducive to the development of this system. With fire suppression, this system expanded into sites formerly occupied by disturbance maintained savannas (Leach & Givnish 1999). Historically, this system represented a small percentage of the oak forest and savanna types (Curtis 1959).

For LANDFIRE mapping, SSURGO map units with moderate to high silt percentages (>40%) on uplands, with taxonomic particle sizes of “fine-silty” or “fine-loamy over sandy” may prove useful for mapping this
system. Sites expected to have higher fire frequencies on “fine-loamy” may be included for mapping this system, whereas lower frequencies on these sites would likely indicate North-Central Interior Maple-Basswood Forest (1314). Soil orders are generally Alifsols with Mollisols becoming more important at the interface with prairie and savanna systems.

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Vegetation Description

Typically, the vegetation consists of forests dominated by oaks, especially white oak (Quercus alba), black oak (Quercus velutina), and red oak (Quercus rubra). Black oaks were generally more abundant on more xeric, sandier sites, whereas red oak was generally more abundant on more mesic, loamier sites. Red oak can also develop under a moderate overstory of the other oaks. Bur oak was occasionally present on sites with higher fire frequency or on thin calcareous soils (Curtis 1959). White oak spans the range of edaphic conditions encapsulated by this system. Prunus serotina capitalizes on canopy gaps, but rarely achieves significant canopy dominance (McCune and Cottam 1985). Other hardwood species, including Juglans nigra, Juglans cinerea, Celtis occidentalis, Ulmus americana and Acer negundo were occasionally found in the southern extent of this system on more mesic sites with lower fire frequencies. Along with oaks are varying amounts of hickory (Carya glabra and Carya ovata), red maple (Acer rubrum), black cherry (Prunus serotina) and sassafras (Sassafras albidum). Subcanopies and shrub layers are usually well-developed by witch-hazel (Hamamelis virginiana), flowering dogwood (Cornus florida) and hop-hornbeam (Ostrya virginiana). Common low woody shrubs include brambles (Rubus spp.), black currant (Ribes cynosbati), and both native and invasive roses (Rosa spp.). Graminoid species such as Carex pensylvanica, Danthonia spicata and Andropogon gerardii are also common.

Disturbance Description

The North-Central Interior Dry-Mesic Oak Forest and Woodland (oak-hickory forest) is predominantly Fire Regime I, characterized by low-severity surface fires. Historically, indigenous fires accounted for over 95% of the ignitions over these landscapes. Vegetation types varied based on fire frequency and intensity. Grassland prairies burned often with fire rotations approximately less than five years and were probably associated with flat-to-slightly rolling terrain that effectively carried fire (Anderson 1999). These grasslands, deliberately maintained by Native Americans for hunting purposes, were probably scattered throughout the forest matrix. Oak-hickory savannas occurred where fire frequency was a bit less, probably 5-15yrs. Woodlands developed within a moderate burning regime, with fire return times averaging every 15-25yrs. Closed-canopy oak-hickory forests would develop where fire return intervals stretched beyond 25yrs. Shade-tolerant, fire-sensitive maples (and associated late-successional trees) would regenerate and form understories beneath oak-hickory canopies when fire was excluded over many decades (50yrs). With continued fire exclusion, maple and other late-successional species would gradually replace overstory oaks and hickories through gap capture (Sutherland et al 2003). A mosaic of vegetation types comprised oak-hickory landscapes contingent on fire history (Cutter and Guyette 1994). From a gross landscape perspective, oak-hickory forests occurred in a contiguous matrix integrated with oak savannas, grassland prairies, and mesic forests dominated by red and sugar maple. Fire frequency and intensity determined the proportion of each of these landscape ecosystems across the landscape matrix. Historically, grazing would have similarly maintained open conditions in savannas and cause problems for oak species in recruiting into the overstory. Ice-damage, periodic insect defoliation, and the extinct passenger pigeon may have likely contributed to increased oak canopy openings that facilitated light penetration to the forest floor, and, ultimately, greater possibility of germination and recruitment of oaks.

Native Americans played a critical role in the development and maintenance of oak-hickory landscapes through fire ignition. Natives burned these landscapes for a variety of reasons. Fire encouraged open habitats which, in turn, increased food-producing plants (forbs, mast) and ungulate herbivores (meat). Also, lightning-strike ignitions, though limited in frequency, would have provided an additional source of ignition.

Adjacency or Identification Concerns

Though often contiguous, oak-hickory patches are virtually always integrated in the larger landscape scale

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with mesic maple-dominated forests and dry oak savannas. Mesic maple forests were relegated to those areas where fire was restricted through facilitation by an edaphic factor such as heavy-textured soil or high water table or by natural fire breaks such as bodies of water and slightly protected depressions. Prolonged intervals (100-150yrs) without fire were needed for maples to manifest their dominance. Oak-hickory forests also graded into savannas (i.e., oak openings) when fire intervals shortened to the point where woody regeneration of overstory tree species was limited. Exposed areas where wind could carry flames at great distances tend to exhibit more savanna vegetation structure than a close oak-hickory forest. In areas where flat outwash extended beyond ice-contact terrain or end moraine, savannas would typically occur in the former abutting a closed forest on the latter landforms. Currently, under the past century's practice of fire suppression, oak-hickory forests are succeeding into a red maple-dominated forest. Prolific sprouting ability, light, wind-carried fruits and the tendency to cast dense shade has enabled red maple to out compete white and black oak in these systems. Without fire as a natural disturbance that prevents establishment of fire-sensitive species, mesophytic species are free to invade and recruit into the overstory. Implications to forestry, wildlife, and pest and disease outbreaks become apparent.

Native Uncharacteristic Conditions

Though present historically, red maple has been typified as the "native invasive" in oak hickory forests. Its abundance in these systems measured in both stem density and basal area has grown considerably due to fire suppression and the marked increase in fire return interval. Abundance of aspen, sassafras and black cherry can also be attributed to fire suppression and poor silviculture practices.

Scale Description

Pre-European oak-hickory forests covered hundreds of thousands of contiguous acres. When considered as a matrix with savannas and prairies, estimated acreage increases significantly.

Issues/Problems

This system has largely converted to closed-canopy forests progressively increasing in mesophytic species. As these systems become increasing mesophytic, the ability to get fire back on the landscape becomes increasingly difficult.

Native grazing, due to higher deer densities than historically (at least in WI) further suppress recruitment of oaks and exacerbates the trend toward closed-canopy mesophytic species. Invasive species, including buckthorn (Rhamnus cathartica) and honeysuckle (Lonicera spp.) are becoming increasingly prevalent in the understories of some stands.

Comments

NOTE 5/20/08: As a result of final QC for LANDFIRE National by Jennifer Long the user-defined min and max fire return intervals for replacement and surface severity fire were deleted because they were not consistent with the modeled fire return interval for these fire severity types.

Following the model evolution is inserted comments from a reviewer-these were not incorporated due to modeler concerns, but should be considered when using this model.

This model was largely adopted from Kost and Lee who in turn adopted from R6OAHI by Daniel Yaussy and Aaron Kloss.

Comments from R6OAHI model: This model replaces the model R8OAKdm from the Southern Appalachians model zone. This is a modification of the OKH4 FRCC model developed by Nowacki,

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Hutchinson, Iverson and Van-Gundy. We added a pathway from Class B to Class E to represent a portion of the landscape that is too moist to burn. Possible reviewers: Greg Nowacki, Marc Abrams, Burton Barnes (bvb@umich.edu), Dennis Albert, Joshua Cohen.

Reviewer comments:

For SClass B: Mixed fire is not operating as a maintenance disturbance because it does not set age back. This can be a steady state expression of this system if fire frequency is high enough (though overlapping with savanna concept, many of which proved to be seral to this system), with older very sparse oaks. Allow this to succeed to itself, and use a TSD of 10yrs to kick this over to C.

SClass C. Surface fire does not maintain class in this state because it does not reset age. Use similar fix as for B: TSD = 20. MFRI should be comparable to B for a total of 18yrs. This class also needs a mixed fire that maintains in this state (canopy thinning fire that doesn't remove oldest cohort or thin to below 20% cover). With a p=0.015 (equivalent to the C->B mixed fire), this brings the MFRI to 18yrs for this class and is a reasonable split of outcomes: 27% of fires leave some trees <20% cover; 27% thin with tree cover >20%; 36% burn with no significant effect to canopy; and 9% remove everything. The reviewer suggests that the mortality rates of the younger oaks are on par with the fire susceptibility that Curtis (1959) explains for these oaks, though Curtis doesn't mention much about fire frequency.

Based on Curtis, the reviewer suggests that there should be more of this – a more even spread between this class and the forest class (which has increased significantly in current forests). Replace ANGE in species list with QUMA2.

SClass D. Surface fire doesn't maintain this type as intended (and effectively acts like a 125yr TSD rather than the 50yrs in description for this class), use TSD=100 to E and allow this to succeed to itself. Maintenance fire (surface) frequency should be higher, for a net fire probability equivalent to A-C of about 0.055. I increased surface fire to p=0.025. The oaks are going to have a hard time getting solid regeneration in this class (Curtis 1959), they really need a major canopy opening disturbance to kick it to a more open state (C) before they can establish more successfully.

Notes: The TSD values required some tinkering to get the right proportions by SClass, because of the large number of fire disturbances in mid/later classes that kick stands to a different class (thus negating the effect of TSD). TSD only applies to recording of disturbances within a given SClass (maintenance disturbances). If the only disturbances were maintenance surface fires, this would have been straightforward with ecologically meaningful values.

Final proportions from VDDT:
A: 3%
B: 12%
C: 37%
D: 43%
E: 5%
MFRI = 20.

References:
Add
Curtis, J.T. 1959. The Vegetation of Wisconsin. University of Wisconsin Press, Madison, WI.

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100-year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement seve

Leach, M.K. and T.J. Givnish. 1999. Gradients in the composition, structure, and diversity of remnant oak savannas in southern Wisconsin. Ecological Monographs 69(3): 353-374.

McCune, B. and G. Cottam. The successional status of a southern Wisconsin oak woods. Ecology 66(4): 1270-1278.

Vegetation Classes

Class A 2 %

Early Development 1 All Structure

Upper Layer Lifeform

- [x] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model

Indicator Species* and Canopy Position

ANGE	Upper
SCHIZ4	Upper
SONU2	Upper

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	100 %
Height	Herb 0m	Herb >1.1m
Tree Size Class	None	

[ ] Upper layer lifeform differs from dominant lifeform.

Description

PRAIRIE. This class ranges from 0-4yrs and succeeds to class B. Class A is grassland prairie maintained by frequently recurring fire. Replacement fire was modeled with the probability of occurring every 10yrs. Native Americans used these lands for hunting, and agriculture/native plant gathering. If fire is absent for a few years, tree seedlings and sprouts would recruit into trees and form savannas. Heavy grazing, though unlikely to have large-scale impact, would have kept certain patches from progressing to a woody shrub vegetation stage and would have maintained class A. Native grazing was modeled with the probability of occurring every 100yrs.

Class B 12 %

Mid Development 1 Open

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model

Indicator Species* and Canopy Position

QUAL	Upper
QUVE	Upper
ANGE	Lower
SCHIZ4	Lower

Structure Data (for upper layer lifeform)

	Min	Max
Cover	11 %	20 %
Height	Tree 0m	Tree 25m
Tree Size Class	Large 21-33"DBH	

[ ] Upper layer lifeform differs from dominant lifeform.

Description

SAVANNA. This class ranges from 5-14yrs and succeeds to class C. Savannas conditions occurred where fire was fairly frequent allowing some trees to develop (5-15 yrs). Any area that does not burn frequently would convert to woodland conditions (class C). Replacement fire, modeled at the probability of occurring every 40yrs, would send class B to class A. Surface fire, modeled at the probability of occurring every 33yrs, would maintain the system in this class. Native grazing, modeled at the probability of occurring every 100yrs, would also maintain the system in this class.

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Class C 19 %

Mid Development 2 Open

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 9

Indicator Species* and Canopy Position

QUAL	Upper
QUVE	Upper
SAAL5	Upper
QUMA2	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	21 %	60 %
Height	Tree 5.1m	Tree 25m
Tree Size Class	Large 21-33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

WOODLAND. This class ranges in age from 15-24yrs. This class is defined as oak woodland where fire occurred every 15-25 yrs. The canopy closure was less than 60%.

Surface fire, modeled at the probability of occurring every 50yrs, maintains the system in this class. Replacement fire, modeled at the probability of occurring every 66yrs, would send the system back to class B. Replacement fire, modeled at the probability of occurring every 200yrs, would send the system back to class A.

Class D 59 %

Mid Development 3 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 9

Indicator Species* and Canopy Position

QUAL	Upper
QUVE	Upper
QURU	Upper
CAGL8	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	61 %	80 %
Height	Tree 10.1m	Tree 25m
Tree Size Class	Large 21-33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

OAK FOREST. Class D is defined as oak-hickory forest. The age class is 51 indefinite years as long as surface fire occurs periodically. If the late-succession open forest type persists for 50yrs without any type of fire, it will convert to a late-succession mixed mesophytic closed forest type (class E). This conversion is a result of species shift from dominant oaks to dominant maple and beech, which do not support fire as readily.

Surface fire, modeled at the probability of occurring every 100yrs, would maintain this class. Replacement fire, modeled at the probability of occurring every 50yrs, would transition class D to class C. Replacement fire, modeled at the probability of occurring every 100yrs, would transition class D to class B. Replacement fire, modeled at the probability of occurring every 500yrs, would transition class D to class A.

Class E 8 %

Late Development 2 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 8

Indicator Species* and Canopy Position

ACRU	Upper
ACSA3	Upper
TIAM	Upper
QUAL	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	81 %	100 %
Height	Tree 10.1m	Tree 25m
Tree Size Class	Large 21-33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

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MESOPHYTIC FOREST. Maple forests develop during the absence of fire. Dense understories of shade-tolerant species develop. Surface fires would allow these systems to revert back to oak dominance. A replacement fire, modeled at the probability of occurring every 700-1000yrs, could take the system back to A, B,C or D. Infrequent wind/weather/stress modeled at the probability of occurring every 700-1000yrs would maintain the system in this class. These systems often arise on more moist sites adjacent to/on lee sides of streams, rivers and lakes that serve as fire barriers.

Disturbances

Fire Regime Group:** I

Historical Fire Size (acres)

Avg 100
Min 10
Max 1000

Sources of Fire Regime Data

- [x] Literature
- [ ] Local Data
- [x] Expert Estimate

Fire Intervals	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	126.6			0.0079	19
Mixed	50.51			0.0198	48
Surface	74.63			0.0134	33
All Fires	24			0.0411	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fir combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inver of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- [ ] Insects/Disease
- [x] Wind/Weather/Stress
- [x] Native Grazing
- [ ] Competition
- [ ] Other (optional 1)
- [ ] Other (optional 2)

References

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LANDFIRE Biophysical Setting Model

***Biophysical Setting* 5013110** **North-Central Interior Dry Oak Forest and Woodland**

☐ *This BPS is lumped with:*
☐ *This BPS is split into multiple models:*

General Information

Contributors (also see the Comments field **Date** 3/16/2007

Modeler 1	Greg Nowacki	gnowacki@fs.fed.us	**Reviewer**	Dave Cleland	dcleland@fs.fed.us
Modeler 2			**Reviewer**	Brendan Ward	bward@fs.fed.us
Modeler 3			**Reviewer**		

Vegetation Type
Forest and Woodland

Map Zone
50

Model Zone
☐ Alaska ☐ N-Cent.Rockies
☐ California ☐ Pacific Northwest
☐ Great Basin ☐ South Central
☑ Great Lakes ☐ Southeast
☐ Northeast ☐ S. Appalachians
☐ Northern Plains ☐ Southwest

Dominant Species*

QUAL	CAGL8
QUVE	PRSE2
QUEL	SAAL5
QUCO2	QUMA2

General Model Sources
☑ Literature
☑ Local Data
☑ Expert Estimate

Geographic Range
Province 222. For MI 222J. For WI 222K, L and R.

Biophysical Site Description
This system occurs most commonly on interlobates where outwash, ice-contact and end moraine landforms are situated between former glacial lobes. Other landforms suitable for development of the dry oak forest are sandy lake plain and dunes. Common to all these landforms is somewhat excessively drained, acidic soil characterized by sand and loamy sand. Dry landscape settings, such as on western and southern aspects and upper slopes and ridge tops are conducive to the development of this system.

Vegetation Description
Oaks dominated the presettlement vegetation, especially white oak (Quercus alba), black oak (Quercus velutina), northern pin oak (Quercus ellipsoidalis) and bur oak (Quercus macrocarpa). This system is distinguished from North-Central Interior Dry-Mesic Oak Forest and Woodland (1310) by stronger dominance of black oak and northern pin oak, and a general lack of red oak except in later seral stages. Associates include pignut hickory (Carya glabra), red maple (Acer rubrum), black cherry (Prunus serotina) and sassafras (Sassafras albidum). American chestnut (Castanea dentata), now lagely eliminated due to chestnut blight, was an infrequent associate in the very far southeastern portion of Michigan. Small trees associates include witch-hazel (Hamamelis virginiana), flowering dogwood (Cornus florida) and hop-hornbeam (Ostrya virginiana). Common low woody shrubs include brambles (Rubus spp.), black currant (Ribes cynosbati) and native roses (Rosa spp.). Graminoid species such as Carex pensylvanica, Danthonia spicata, Andropogon gerardii are also common. In the most acidic lake plain physiographic systems, ericaceous shrubs such as wintergreen (Gualtheria procumbens), lowbush blueberry (Vaccinium angustifolium), huckleberry (Gaylussacia baccata) become common. Bracken fern (Pteridium aquilinum)

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can be dominant in the most nutrient poor outwash and lake plain landscapes.

Disturbance Description

The North-Central Interior Dry Oak Forest and Woodland is predominantly Fire Regime I, characterized by low-to-moderate severity surface fires. Historically, indigenous fires accounted for over 95% of the ignitions over these landscapes. Vegetation types varied based on fire frequency and severity. Grassland prairies burned frequently (annually or biennially) and were strongly associated with flat-to-slightly rolling terrain that effectively carried fire (Anderson 1999). These grasslands, deliberately maintained by Native Americans for hunting purposes, were probably scattered throughout the forest matrix. Oak grubs (tree-sprout and shrub thickets) occurred where fire frequency was a bit less, probably 5-10 yrs. Also, grub conditions would arise immediately after catastrophic burns that would top-kill tree-dominated communities. Savannas and woodlands developed within a moderate burning regime, with fire return times averaging every 4-17 yrs (Henderson and Long, 1984). Closed-canopy oak forests would develop where fire return intervals stretched beyond 20-40yrs (Crow, 1988) . Shade-tolerant, fire-sensitive maples (and associated late-successional trees) would regenerate and form understories beneath oak canopies when fire was excluded over several decades. With continued fire exclusion, maple and other late-successional species would gradually replace overstory oaks through gap capture (Sutherland and Hutchinson 2003). These shade-tolerant species would eventually form layered stratums of differing heights that will modify the microclimate and light environment to favor self-replacement with exclusion of oaks. A mosaic of vegetation types comprised oak landscapes contingent on fire history (Cutter and Guyette 1994). From a gross landscape perspective, oak forests occurred in a contiguous matrix integrated with oak savannas, grassland prairies, and mesic forests dominated by red and sugar maple. Fire frequency and intensity determined the proportion of each of these landscape ecosystems across the landscape matrix. Historically, grazing would have similarly maintained open conditions in savannas and cause problems for oak species in recruiting into the overstory. Ungulate grazing was probably an important contributing factor maintaining oak-dominated openlands (savannas and woodlands) in presettlement times. Currently, an overabundance of deer is limiting oak regeneration in remnant oak forests in southern MI. Ice-damage, periodic insect defoliation and the extinct passenger pigeon may have likely contributed to increased oak canopy openings that facilitated light penetration to the forest floor, and, ultimately, greater possibility of germination and recruitment of oaks. Native Americans played a critical role in the development and maintenance of oak-hickory landscapes through fire ignition. Natives burned these landscapes for a variety of reasons. Fire encouraged open habitats which, in turn, increased food-producing plants (forbs, mast) and ungulate herbivores (meat). Also, lightning-strike ignitions, though limited in frequency, would have provided an additional source of ignition.

Adjacency or Identification Concerns

This type intergrades and can be easily confused with North-Central Interior Dry-Mesic Oak Forest and Woodland (1310). Fire suppression within the last century has allowed this system to be converted to that system on the loamier soils within the historic range of this type. This type can be distinguished from the Dry-Mesic Oak Forest and Woodland by somewhat sandier soils ore more exposed topographic settings with higher incoming solar radiation (south and west facing slopes).

This type can intergrade with North-Central Oak Barrens (1395), especially in 222R and northwestern 222K, but can be distinguished by occupying sites that are less excessively drained and more silty than those of the barrens. Soils are generally more well-drained than for the Dry-Mesic Oak Forest and Woodland, but are not excessively sandy as for the Oak Barrens.

This type is also found on steep, dry south and west facing slopes and the tops of bluffs in Section 222L where it intergrades with Paleozoic Plateau Bluff and Talus (1517).

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Though often contiguous, oak patches are virtually always integrated in the larger landscape scale with mesic maple-dominated forests, dry-mesic oak-hickory forests and dry oak barrens. Mesic maple forests were relegated to those areas where fire was restricted through facilitation by an edaphic factor such as heavy-textured soil or high water table or by natural fire breaks such as bodies of water and slightly protected depressions. Prolonged intervals (100-150yrs) were needed for maples to manifest their dominance. Dry-mesic oak-hickory forests often occurred adjacent to dry oak forests, defined by a topographic position that had more amenable well-drained soil, lower solar radiation, better moisture conditions, and more protection from drying winds and recurring fires. Lower slopes on north and east aspects were typical of oak-hickory forests whereas ridge tops and upper slopes on south and west aspects favored dry oak forests. Oak forests also graded into savannas and barrens (i.e., oak openings) when fire intervals shortened to the point where woody regeneration of overstory tree species was limited. Exposed areas where wind could carry flames at great distances tend to exhibit more savanna vegetation structure than a close oak forest. In areas where flat outwash extended beyond ice-contact terrain or end moraine, savannas would typically occur in the former abutting a closed forest on the latter landforms. Fires often burned from a west to east direction and stopped on the western edge of rivers (Gleason, 1913), leaving eastern edges forested. Currently, under the past century's practice of fire suppression, oak forests are succeeding into a red maple-dominated forest. Prolific sprouting ability, light, wind-carried fruits, and the tendency to cast dense shade has enabled red maple to out compete white and black oak in these systems. Without fire as a natural disturbance that prevents establishment of fire-sensitive species, mesophytic species are free to invade and recruit into the overstory. Furthermore, due to the naturally short life span of northern pin oak, red maple is poised to maintain its dominance once it has established a stable population. Its modifying affects on understory shade and quick nutrient uptake will exclude the understory intolerant northern pin oak. Implications to forestry, wildlife, and pest and disease outbreaks become apparent in the future.

Today, with fragmentation, development, and mesophytic species invasion, few original dry oak forest remain. However, succession of previous oak barrens, such as in Allegan County, to closed oak forests has added to the total area of current dry oak forests.

Native Uncharacteristic Conditions

Though present historically, red maple has been typified as the "native invasive" in oak forests. Its abundance in these systems measured in both stem density and basal area has grown considerably due to fire suppression and the marked increase in fire return interval. Abundance of aspen, sassafras, and black cherry can also be attributed to fire suppression and poor silvicultural practices.

Scale Description

Pre-European oak forests covered hundreds of thousands of contiguous acres. When considered as a matrix with savannas and prairies, estimated acreage increases significantly.

Issues/Problems

Native grazing, due to higher deer densities than historically (at least in WI) further suppress recruitment of oaks and exacerbates the trend toward closed-canopy mesophytic species. Invasive species, including garlic mustard (Alliaria petiolata), buckthorn (Rhamnus cathartica), and honeysuckle (Lonicera spp.) are becoming increasingly prevalent in the understories of some stands.

Comments

NOTE 5/20/08: As a result of final QC for LANDFIRE National by Jennifer Long the user-defined min

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100-year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement seve

and max fire return intervals for replacement and mixed severity fire were deleted because they were not consistent with the modeled fire return interval for these fire severity types.

This model was larglely adopted from Kost and Lee (5113110 who adopted their model from R6OAHI by Daniel Yaussy and Aaron Kloss.

Comments from R6OAHI: This model replaces the model R8OAKdm from the Southern Appalachians model zone. This is a modification of the OKH4 FRCC model developed by Nowacki, Hutchinson, Iverson, and Van-Gundy. We added a pathway from class B to class E to represent a portion of the landscape that is too moist to burn. Possible reviewers: Greg Nowacki, Marc Abrams, Burton Barnes (bvb@umich.edu), Dennis Albert, Joshua Cohen.

Vegetation Classes

Class A 4 %

Early Development 1 All Structure

Upper Layer Lifeform

- [x] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model 3

Indicator Species* and Canopy Position

ANGE	Upper
SCHIZ4	Upper
SONU2	Upper

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	100 %
Height	Herb 0.6m	Herb >1.1m
Tree Size Class		

- [ ] Upper layer lifeform differs from dominant lifeform.

Description

PRAIRIE. Class A is grassland prairie maintained by frequent fire (mean fire return interval = five years). Native Americans burned these areas frequently to maintain habitat for ungulates (hunting) and native plant gathering. If fire is absent for a few years (four years plus), tree seedlings or sprouts from "grubs" (sprouts from ancient root systems) would be released, moving the community to savanna conditions. Heavy grazing, though unlikely to have large-scale impact, would have kept certain patches from progressing to a woody shrub vegetation stage and would have helped maintained these grasslands.

Class B 25 %

Mid Development 1 Open

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model 1

Indicator Species* and Canopy Position

QUAL	Upper
QUVE	Upper
ANGE	Lower
SCHIZ4	Lower

Structure Data (for upper layer lifeform)

	Min	Max
Cover	11 %	30 %
Height	Tree 0m	Tree 10m
Tree Size Class	Large 21-33"DBH	

- [ ] Upper layer lifeform differs from dominant lifeform.

Description

SAVANNA. This is an open system with a scattering of trees (10-25% tree cover). Savannas were maintained by surface burns occurring every 10yrs. Areas that did not burn at this frequency would convert to woodlands. Grazing helped maintain the openness of this system.

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Class C 36 %

Mid Development 2 Open

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 9

Indicator Species* and Canopy Position

QUAL	Upper
QUVE	Upper
QUEL	Upper
CAGL8	Upper

Structure Data (for upper layer lifeform)

	Min	Max
Cover	31 %	60 %
Height	Tree 5.1m	Tree 25m
Tree Size Class	Large 21-33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

WOODLAND. This class is defined as oak woodland. The canopy closure is less than 60% but >25%. Woodlands were maintained by surface fire frequency occurring every 25yrs. If fire is absent from this community for an extended period (e.g., 50yrs), stand density continues to increase, moving the community to a closed-canopy (60-100%), oak forest (class D).
An occasional replacement fire (500 yr MFRI) will move this community back to a open grassland stage. There are mixed fires that can send cells from C to either C or B depending on conditions every 100yrs.

Class D 30 %

Late Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 9

Indicator Species* and Canopy Position

QUAL	Upper
QUVE	Upper
QUEL	Upper
CAGL8	Upper

Structure Data (for upper layer lifeform)

	Min	Max
Cover	81 %	100 %
Height	Tree 10.1m	Tree 25m
Tree Size Class	Large 21-33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

OAK FOREST. Class D is defined as a closed-canopy oak forest. Infrequent fire (every 50yrs) maintained open understories with some oak regeneration. During extended period of no fire, these forests would convert to mesophytic species, especially along rivers and streams that served as fire barriers. This conversion is a result of species shift from dominant oaks to dominant maple, basswood and beech, which do not support fire as readily.

Class E 5 %

Late Development 2 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 8

Indicator Species* and Canopy Position

ACRU	Upper
ACSA3	Upper
TIAM	Upper
QUAL	Upper

Structure Data (for upper layer lifeform)

	Min	Max
Cover	61 %	80 %
Height	Tree 5.1m	Tree 25m
Tree Size Class	Large 21-33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

MESOPHYTIC FOREST. Closed-canopy, mixed mesophytic forests would develop under the absence of fire for extended periods (150yrs). Dense, multi-canopied understories of shade-tolerant species would develop. Class E is characterized by closed canopy forest that can persist in the absence of disturbance. Surface fires had little effect due to the prevailing mesophytic conditions (cool and damp understory conditions; moist retaining and rapidly decaying leaf litter). Replacement fires are very rare and would revert the system to early succession open class A.

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Disturbances

Fire Regime Group:** I

Historical Fire Size (acres)

Avg 100
Min 10
Max 1000

Sources of Fire Regime Data

- [x] Literature
- [ ] Local Data
- [x] Expert Estimate

Fire Intervals	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	96.15			0.0104	16
Mixed	1010			0.00099	2
Surface	18.94	2	25	0.0528	82
All Fires	16			0.06419	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fir combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inver of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- [ ] Insects/Disease
- [x] Wind/Weather/Stress
- [x] Native Grazing
- [ ] Competition
- [ ] Other (optional 1)
- [ ] Other (optional 2)

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LANDFIRE Biophysical Setting Model

Biophysical Setting 5013130 North-Central Interior Beech-Maple Forest

☐ *This BPS is lumped with:*
☐ *This BPS is split into multiple models:*

General Information

Contributors (also see the Comments field **Date** 4/25/2007

Modeler 1 Becky Schillo schillor@michigan.gov **Reviewer** Dave Cleland dcleland@fs.fed.us
Modeler 2 **Reviewer**
Modeler 3 **Reviewer**

Vegetation Type
Forest and Woodland

Map Zone
50

Model Zone
☐ Alaska ☐ N-Cent.Rockies
☐ California ☐ Pacific Northwest
☐ Great Basin ☐ South Central
☑ Great Lakes ☐ Southeast
☐ Northeast ☐ S. Appalachians
☐ Northern Plains ☐ Southwest

Dominant Species*
ACSA3 QURU
TIAM CACA18
POTR5 ULAM
FAGR FRPE

General Model Sources
☑ Literature
☐ Local Data
☐ Expert Estimate

Geographic Range

This mesic forest type extends through MI and eastern WI, and is limited by the distribution of beech (Fagus grandifolia). North of the tension zone in WI and MI, this would be replaced by the Laurentian-Acadian Northern Hardwoods Forest system (13020). In MZ51, this system replaces the North-Central Interior Maple-Basswood Forest (13140).

In MZ50, this type is limited to subsections 222Kc, 222Ke, 222Kf, 222Kg.

Biophysical Site Description

The North-Central Interior Beech-Maple forest occurred on rich, mesic sites that were protected from fire by the oak-aspen buffer lying between this community and the prairie and or by natural fuel breaks. They also occurred on upland sites with moist soils, usually in settings protected from fire.

For LANDFIRE mapping, soils are generally Alfisols, with low percentages of sand (<15%) and moderate percentages of silt (>30%). SSURGO taxonomic particle sizes of “fine,” “fine-silty,” “fine-loamy,” “loamy” are associated with the distribution of this system.”

Plants in these communities have access to predictable supplies of water and nutrients, but they are often limited by light because of the dense forest canopy. Typical sites are buffered from seasonal drought by fine-textured moisture-retaining soils or dense subsoil layers. Essential nutrients are mineralized from decaying organic matter at twice the rate of that in fire-dependent forest or wet forest communities.

Vegetation Description

Sites are characterized by continuous, often dense, canopies of deciduous trees and understories of shade-adapted shrubs and herbs. Dominant trees species in the canopy and subcanopy include sugar maple,

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beech, basswood, northern red oak, red elm, American elm, ironwood, bitternut hickory, black ask, green ash and muscle wood. Canopy associates may include white oak, hackberry, butternut, black walnut, black cherry, yellow birch and Kentucky coffee-tree. The sparse shrub layer is dominated by sugar maple and other young tree species in addition to prickly gooseberry, chokecherry, alternate leaved dogwood, prickly ash, and red-berried elder (MNDNR 2005).

The ground flora is dominated by spring ephermals which complete their life cycle in the spring before the canopy trees have leafed out and cast a dense shade on the understory. Common ground cover species include Dutchman's breeches (Dicentra cucullaria), cut-leaved toothwort (Cardamine concatenata), bloodroot (Sanguinaria canadensis), Virginia waterleaf (Hydrophyllum virginianum), violet (Viola pubescens), wild leek (Allium tricoccum), blue cohosh (Caulophyllum thalictroides), early meadow-rue (Thalictrum dioicum), bedstraw (Galium aparine), sweet cicely (Osmorhiza claytonii), jack-in-the-pulpit (Arisaema triphyllum), trilliums (Trillium spp.) and wood anemone (Anemone quinquefolia). (MNDNR 2005, Curtis 1959)

Disturbance Description

Fire Regime V characterizes this system, dominated by high-intensity, low-frequency fires that occur in greater than 1000yr intervals. Low-intensity fires surface fires may have been more frequent in the mid-seral stages of this BpS when more fire-prone species (such as oak) comprise a larger component of the tree canopy. Light surface fires would result in the partial loss of trees, and are estimated at a rotation of about 50yrs (MNDNR 2005).

Historically, this forest type, composed of fire-sensitive species, was not disturbed by fire except during periods following catastrophic wind events or extreme drought. Grimm (1984) states “The fire regimes of deciduous forests, such as bigwoods, are much different from the commonly perceived model of fire regime, in which fuels and fire danger increase with time and in which intense crown fires cause great destruction of the forest.” In maple-basswood forests, decomposition of potential fuels is rapid, and is particularly rapid on base-rich soils (Bormann and Likens 1979), such as those of the Big Woods. Because of the dense shade, the cover of herbs and shrubs is sparse. Thus little fuel exists at the ground level, tree trunks are not very flammable, and the open tree crowns do not carry fire very well. Moreover, low solar radiation, high humidity, and low wind speeds prolong the moisture retention of ground-level fuels (Kucera 1952), thereby inhibiting the ignition and spread of fire. These forests are sometimes referred to as the “asbestos forests” because of their fireproof character (Vogl 1967). Ordinarily, only the leaf litter ever reaches a flammable state, and only patchy creeping ground fires occur (Niering et al. 1970, Barden and Woods 1973).

Two primary disturbance factors are used to model this system. Catastrophic windthrow affects mature stands and occurs on an approximately 600-700yr rotation (MNDNR 2005). Replacement fire occurs primarily in young and windthrown stands and occurs on a rotation of approximately 1000yrs. In addition, surface fires occur in young stands <100yrs of age which contain a significant component of oak. The disturbance probabilities by class applied in the model are contained in the VDDT documentation section.

Adjacency or Identification Concerns

This model is functionally lumped with North-Central Interior Maple Basswood Forest (13140) in MZs 50 and 51.

Historically, elm was a canopy component within the maple-beech forest (Grimm 1981). However, this species has been largely eliminated from this system due to Dutch elm disease. American elm (Ulmus americana) is now generally only present in the understory and midstory in contemporary forests, whereas

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historically it would have been the occasional canopy dominant.

Uncharacteristic conditions in this setting include infestation by exotic earthworms of European species that have affected or begun to affect soil conditions, herb/forb species representation, and tree regeneration (Hale et al. 1999). Habitat for the rare Great Lakes endemic fern, Botrychium mormo, is largely eliminated after worm invasion.

Native Uncharacteristic Conditions

Scale Description

The most common disturbance extent could best be characterized as a single-tree or small-group gap-phase dynamic. Replacement events would have encompassed hundreds to thousands of acres. Patch sizes would generally conform to landforms on which they are found.

Issues/Problems

This model was duplicated from 4113140 modeled by Becky Schillo. Textual revisions were made 7/05/07 by Brendan C. Ward.

Comments

This model adapted from the Rapid Assessment Model R6MABA Maple Basswood by Greg Nowacki (gnowacki@fs.fed.us), Dave Cleland (dcleland@fs.fed.us) and Jim Gallagher (jagallagher@fs.fed.us)

Comments from R6MABA: Model R6MABA is unmodified from FRCC model for MABA. REVIEWERS: John Almendinger, Ecological Services, MN Department of Natural Resources. Jim Barott, Chippewa National Forest. Reviewed and entered by Jim Gallagher, Chippewa NF.

Vegetation Classes

Class A 8 %

Early Development 1 All Structure

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 5

Indicator Species* and Canopy Position

POTR5	Upper
TIAM	Upper
QURU	Upper
ACSA3	Upper

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	100 %
Height	Tree 0m	Tree 5m
Tree Size Class	Pole 5-9" DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Characterized by early-seral young forest following a catastrophic wind or fire event. Young forest dominated by aspen, birch, northern red oak, basswood and American elm <35yrs. Sugar maple is not likely to establish immediately following fire, but regeneration may be heavy following windthrow events. Class A succeeds to mid-age stands (class B). Replacement fire, modeled with a 1000yr probability, would kill the young tree species and reset the system to time zero.

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Class B 9 %

Mid Development 1 All Structures

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 8

Indicator Species* and Canopy Position

ACSA3	Upper
TIAM	Upper
QURU	Upper
FAGR	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	100 %
Height	Tree 5.1m	Tree 10m
Tree Size Class	Medium 9-21"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Characterized by mid-succession maturing forests (35-70yrs) which succeed to class C. In this stage there is the gradual decline of northern red oak and it is replaced by sugar maple and beech. American elm and basswood increase while aspen senesces and is eliminated from the system. Replacement fires (mostly in slash), modeled with a 1000yr probability, would return the system to class A. There is also the possibility for a light surface fires to carry through this stage (associated with the oak component), modeled with a 70yr probability. The surface fire would kill or set back some, but nor all, trees maintaining the system in this class.

Class C 14 %

Mid Development 2 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 8

Indicator Species* and Canopy Position

ACSA3	Upper
FAGR	Upper
TIAM	Upper
ULAM	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	61 %	100 %
Height	Tree 10.1m	Tree 25m
Tree Size Class	Large 21-33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Characterized by late-successional maturing forests (75-150yrs) which succeed to class D. Forest dominated by sugar maple, beech, basswood, American elm, ironwood, northern red oak. Rare replacement fires, modeled with the probability of occurring every 1000yrs, and windthrow, modeled as wind/weather/stress with a 600-700yr probability would take the system to class A.

Class D 69 %

Late Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 8

Indicator Species* and Canopy Position

ACSA3	Upper
FAGR	Upper
TIAM	Upper
ULAM	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	61 %	100 %
Height	Tree 25.1m	Tree >50.1m
Tree Size Class	Very Large >33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

In this late seral stage there would be a multi-layer canopy and sub-canopy (created through small-scale windthrow). Therefore, although the min tree height is set at 25m in order to make this class exclusive from cass C tree height would range from 10-50m.

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These old late-seral forests (>150yrs) are the end point of succession. Forest dominated by sugar maple, beech, basswood, American elm, ironwood, northern red oak. Small gap disturbances predominate to maintain a high proportion of the acreage in this class. This small scale windthrow was modeled as wind/weather/stress with the probability of occurring every 10yrs and would maintain the system in class D. Rare replacement fires, modeled with the probability of occurring every 1000yrs, and windthrow, modeled as wind/weather/stress with a 600-700yr probability would take the system to class A.

Class E **0 %**

[Not Used] [Not Used]

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☐ Tree

Fuel Model

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	%	%
Height		
Tree Size Class		

☐ Upper layer lifeform differs from dominant lifeform.

Description

Disturbances

Fire Regime Group:** **V**

Historical Fire Size (acres)

Avg 5000
Min 10
Max 10000

Sources of Fire Regime Data

- ☑ Literature
- ☐ Local Data
- ☐ Expert Estimate

Fire Intervals	*Avg FI*	*Min FI*	*Max FI*	*Probability*	*Percent of All Fires*
Replacement	1000			0.001	45
Mixed					
Surface	833.3			0.0012	54
All Fires	454			0.00221	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fir combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inver of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- ☐ Insects/Disease
- ☑ Wind/Weather/Stress
- ☐ Native Grazing
- ☐ Competition
- ☐ Other (optional 1)
- ☐ Other (optional 2)

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Canham, Charles D. and Orie L. Louck. 1984. Catastrophic windthrow in presettlement forests of Wisconsin. Ecology. 65(3): 803-809.

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100-year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement seve

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100-year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement seve

LANDFIRE Biophysical Setting Model

***Biophysical Setting* 5013140** **North-Central Interior Maple-Basswood Forest**

☐ *This BPS is lumped with:*
☐ *This BPS is split into multiple models:*

General Information

Contributors (also see the Comments field **Date** 4/25/2007

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Modeler 2			**Reviewer**	Brendan Ward	bward@fs.fed.us
Modeler 3			**Reviewer**		

Vegetation Type
Forest and Woodland

Map Zone
50

Model Zone
☐ Alaska ☐ N-Cent.Rockies
☐ California ☐ Pacific Northwest
☐ Great Basin ☐ South Central
☑ Great Lakes ☐ Southeast
☐ Northeast ☐ S. Appalachians
☐ Northern Plains ☐ Southwest

Dominant Species*

ACSA3	QURU
TILIA	CACA18
POTR5	ULAM
ULRU	FRPE

General Model Sources
☑ Literature
☐ Local Data
☐ Expert Estimate

Geographic Range

This forest type extends from northern MN and WI southward into IA and IL, and from the forest-prairie margin eastward to Lake Michigan. This forest type is fringed by northern hardwoods to the north and prairies to the west. The western range of beech forms the eastern boundary, whereas its southern margin roughly parallels the maximum extent of past glaciation. The Big Woods of southeastern MN is representative of this forest type (Grimm 1984). In MZ41 this BpS would have occurred in 212 Kb, 212 Nb, and 222 Ma, Mb, Mc, and Md. In MZ50 the BpS would have occurred in 222 kb, Kc, Kd, Ke, Kf, Kg, Kh and 222 Lc, Ld, and Le.

Biophysical Site Description

The North-Central Interior Maple-Basswood Forest occurred on rich, mesic sites that were protected from fire by the oak-aspen buffer lying between this community and the prairie and or by natural fuel breaks. They also occurred on upland sites with moist soils, usually in settings protected from fire. In MN, these fire-protected sites supporting maple-basswood forest occur on the rolling topography of end moraines, the north facing-slopes of till plains, and the middle and lower north-facing slopes of loess-or drift-covered bedrock bluffs (MNDNR 2005). Soils are well-drained loam derived from calcareous till or wind-deposited silt over bedrock (MNDNR 2005).

For LANDFIRE mapping, soils are generally Alfisols, with low percentages of sand (<15%) and moderate percentages of silt (>30%). SSURGO taxonomic particle sizes of “fine,” “fine-silty,” “fine-loamy,” “loamy” are
associated with the distribution of this system.

Plants in these communities have access to predictable supplies of water and nutrients, but they are often

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limited by light because of the dense forest canopy. Typical sites are buffered from seasonal drought by fine-textured moisture-retaining soils or dense subsoil layers. Essential nutrients are mineralized from decaying organic matter at twice the rate of that in fire-dependent forest or wet forest communities.

Following retreat of the glaciers, most of the present Big Woods became prairie between 9000 and 6000yrs before present (Webb et al. 1993). Oak woodland began invading the prairie about 5000yrs ago, becoming fully established 2400yrs ago (Grimm 1981). Oak woodland persisted until 300yrs ago, when elm, basswood, and sugar maple rapidly expanded and became dominant. The changes from prairie to oak woodland, and from oak woodland to maple-basswood 'bigwoods' must have resulted from reductions in fire frequency, which were probably caused by increased precipitation and possibly decreased temperatures (ibid).

Vegetation Description

Sites are characterized by continuous, often dense, canopies of deciduous trees and understories of shade-adapted shrubs and herbs. Dominant trees species in the canopy and subcanopy include sugar maple, basswood, northern red oak, red elm, American elm, ironwood, bitternut hickory and muscle wood. Canopy associates may include white ash, yellow birch, black walnut, white oak, hackberry, butternut, black cherry and Kentucky coffee-tree. In WI, beech may also be a component of the tree canopy (Curtis 1959). The sparse shrub layer is dominated by sugar maple and other young tree species in addition to prickly gooseberry, chokecherry, alternate leaved dogwood, prickly ash and red-berried elder (MNDNR 2005).

The ground flora is dominated by spring ephermals which complete their life cycle in the spring before the canopy trees have leafed out and cast a dense shade on the understory. Common ground cover species include Dutchman's breeches (Dicentra cucullaria), cut-leaved toothwort (Cardamine concatenata), bloodroot (Sanguinaria canadensis), Virginia waterleaf (Hydrophyllum virginianum), violet (Viola pubescens), wild leek (Allium tricoccum), blue cohosh (Caulophyllum thalictroides), early meadow-rue (Thalictrum dioicum), bedstraw (Galium aparine), sweet cicely (Osmorhiza claytonii), jack-in-the-pulpit (Arisaema triphyllum), trilliums (Trillium spp.) and wood anemone (Anemone quinquefolia). (MNDNR 2005, Curtis 1959)

Disturbance Description

Fire Regime V characterizes this system, dominated by high-intensity, low-frequency fires that occur in greater than 1000yr intervals. Low-intensity fires surface fires may have been more frequent in the mid-seral stages of this BpS when more fire-prone species (such as oak) comprise a larger component of the tree canopy. Light surface fires would result in the partial loss of trees, and are estimated at a rotation of about 50yrs (MNDNR 2005).

Historically, this forest type, composed of fire-sensitive species, was not disturbed by fire except during periods following catastrophic wind events or extreme drought. Grimm (1984) states “The fire regimes of deciduous forests, such as bigwoods, are much different from the commonly perceived model of fire regime, in which fuels and fire danger increase with time and in which intense crown fires cause great destruction of the forest.” In maple-basswood forests, decomposition of potential fuels is rapid, and is particularly rapid on base-rich soils (Bormann and Likens 1979), such as those of the Big Woods. Because of the dense shade, the cover of herbs and shrubs is sparse. Thus little fuel exists at the ground level, tree trunks are not very flammable, and the open tree crowns do not carry fire very well. Moreover, low solar radiation, high humidity, and low wind speeds prolong the moisture retention of ground-level fuels (Kucera 1952), thereby inhibiting the ignition and spread of fire. These forests are sometimes referred to as the “asbestos forests” because of their fireproof character (Vogl 1967). Ordinarily, only the leaf litter

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ever reaches a flammable state, and only patchy creeping ground fires occur (Niering et al. 1970, Barden and Woods 1973).

Two primary disturbance factors are used to model this system. Catastrophic windthrow affects mature stands and occurs on an approximately 600-700yr rotation (MNDNR 2005). Replacement fire occurs primarily in young and windthrown stands and occurs on a rotation of approximately 1000yrs. In addition, surface fires occur in young stands <100yrs of age which contain a significant component of oak. The disturbance probabilities by class applied in the model are contained in the VDDT documentation section.

Adjacency or Identification Concerns

Historically, elm was a canopy component within the maple-beech forest (Grimm 1981). However, this species has been largely eliminated from this system due to Dutch elm disease. American elm (Ulmus americana) is now generally only present in the understory and midstory in contemporary forests, whereas historically it would have been the occasional canopy dominant.

Uncharacteristic conditions in this setting include infestation by exotic earthworms of European species that have affected or begun to affect soil conditions, herb/forb species representation, and tree regeneration (Hale et al. 1999). Habitat for the rare Great Lakes endemic fern, Botrychium mormo, is largely eliminated after worm invasion.
Invasive species, including buckthorn and honeysuckle, are increasing in contemporary forests – generally in the southern extent of this BpS.

In many areas, the original distribution of this type has largely been replaced by agriculture except on unsuitable landforms. However, this type has expanded into areas formerly occupied by less mesic forest types
(North-Central Interior Dry-Mesic Oak Forest and Woodland, and North-Central Interior Dry Oak Forest and Woodland) due to fire suppression and high-grading of the oaks. This type can be partially distinguished
during mapping using a combination of aspect and soil information, with this type being limited to the more loamy soils on fire-protected sites and north-facing slopes.

Native Uncharacteristic Conditions

Scale Description

The most common disturbance extent could best be characterized as a single-tree or small-group gap-phase dynamic. Replacement events would have encompassed hundreds to thousands of acres. Patch sizes would generally conform to landforms on which they are found.

Issues/Problems

Comments

This model adapted from the Rapid Assessment Model R6MABA Maple Basswood by Greg Nowacki (gnowacki@fs.fed.us), Dave Cleland (dcleland@fs.fed.us) and Jim Gallagher (jagallagher@fs.fed.us).

Comments from R6MABA: Model R6MABA is unmodified from FRCC model for MABA. REVIEWERS: John Almendinger, Ecological Services, MN Department of Natural Resources. Jim Barott, Chippewa National Forest. Reviewed and entered by Jim Gallagher, Chippewa NF.

Vegetation Classes

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Class A 8 %

Early Development 1 All Structure

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 5

Indicator Species* and Canopy Position

POTR5	Upper
TILIA	Upper
QURU	Upper
ACSA3	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	100 %
Height	Tree 0m	Tree 5m
Tree Size Class	Pole 5-9" DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Characterized by early-seral young forest following a catastrophic wind or fire event. Young forest dominated by aspen, birch, northern red oak, basswood and American elm <35yrs. Class A succeeds to mid-age stands (class B). Replacement fire, modeled with a 1000yr probability, would kill the young tree species and reset the system to time zero. Sugar maple is not likely to establish immediately following fire, but regeneration may be heavy following windthrow events.

Class B 9 %

Mid Development 1 All Structures

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 8

Indicator Species* and Canopy Position

ACSA3	Upper
TILIA	Upper
QURU	Upper
ULAM	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	100 %
Height	Tree 5.1m	Tree 10m
Tree Size Class	Medium 9-21"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Characterized by mid-succession maturing forests (35-70yrs) which succeed to class C. In this stage there is the gradual decline of northern red oak and it is replaced by sugar maple. American elm and ironwood increase while aspen senesces and is eliminated from the system. Replacement fires (mostly in slash), modeled with a 1000yr probability, would return the system to class A. There is also the possibility for a light surface fires to carry through this stage (associated with the oak component), modeled with a 70yr probability. The surface fire would kill or set back some, but nor all, trees maintaining the system in this class.

Class C 14 %

Mid Development 2 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 8

Indicator Species* and Canopy Position

ACSA3	Upper
TILIA	Upper
QURU	Upper
ULAM	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	61 %	100 %
Height	Tree 10.1m	Tree 25m
Tree Size Class	Large 21-33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Characterized by late-successional maturing forests (75-150yrs) which succeed to class D. Forest dominated by sugar maple, basswood, American elm, ironwood, northern red oak. Rare replacement fires, modeled with the probability of occurring every 1000yrs, and windthrow, modeled as wind/weather/stress with a 600-700yr probability would take the system to class A.

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Class D 69 %

Late Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 8

Indicator Species* and Canopy Position

ACSA3	Upper
TILIA	Upper
QURU	Upper
ULAM	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	61 %	100 %
Height	Tree 25.1m	Tree >50.1m
Tree Size Class	Very Large >33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

In this late seral stage there would be a multi-layer canopy and sub-canopy (created through small-scale windthrow). Therefore, although the min tree height is set at 25m in order to make this class exclusive from class C tree height would range from 10-50m.

These old late-seral forests (> 150 yrs) are the end point of succession. Forest dominated by sugar maple, basswood, American elm, ironwood and northern red oak. Small gap disturbances predominate to maintain a high proportion of the acreage in this class. This small scale windthrow was modeled as wind/weather/stress with the probability of occurring every 10yrs and would maintain the system in class D. Rare replacement fires, modeled with the probability of occurring every 1000yrs, and windthrow, modeled as wind/weather/stress with a 600-700yr probability would take the system to class A.

Class E 0 %

[Not Used] [Not Used]

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☐ Tree

Fuel Model

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	%	%
Height		
Tree Size Class		

☐ Upper layer lifeform differs from dominant lifeform.

Description

Disturbances

Fire Regime Group: V**

Historical Fire Size (acres)

Avg 5000
Min 10
Max 10000

Sources of Fire Regime Data

- ☑ Literature
- ☐ Local Data
- ☐ Expert Estimate

Fire Intervals

	Avg FI	*Min FI*	*Max FI*	*Probability*	*Percent of All Fires*
Replacement	9090			0.00011	48
Mixed					
Surface	9090			0.00011	48
All Fires	4524			0.00023	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fir combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inver of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- ☐ Insects/Disease
- ☑ Wind/Weather/Stress
- ☐ Native Grazing
- ☐ Competition
- ☐ Other (optional 1)
- ☐ Other (optional 2)

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100-year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement seve

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LANDFIRE Biophysical Setting Model

Biophysical Setting 5013621 Laurentian-Acadian Northern Pine(-Oak) Forest

☐ *This BPS is lumped with:*
☑ *This BPS is split into multiple models: The complementing models for this model is 1362-1 which does not include oaks.*

General Information

Contributors (also see the Comments field **Date** 6/6/2007

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Vegetation Type
Forest and Woodland

Map Zone
50

Model Zone
☐ Alaska ☐ N-Cent.Rockies
☐ California ☐ Pacific Northwest
☐ Great Basin ☐ South Central
☑ Great Lakes ☐ Southeast
☐ Northeast ☐ S. Appalachians
☐ Northern Plains ☐ Southwest

Dominant Species*
PIBA2 QUEL
PIRE PIST
QURU BEPA
POTR5

General Model Sources
☑ Literature
☑ Local Data
☑ Expert Estimate

Geographic Range

The red pine (Pinus resinosa)/white pine (Pinus strobus)/Oak cover type is found throughout the Great Lakes region including northern MN, WI and MI. In WI the system occurs throughout section 212 (actually can be found anywhere in the state). It also ranges to the eastern US and eastern Canada.

In MN this BpS occurred more specifically in sub-sections 212La, Lb, Lc, Ld and Kb.

Biophysical Site Description

The relative lack of fire protection due to homogeneous landscape patterns and absence of natural fuel breaks (Bergeron and Brisson 1990), as well as localized edaphic conditions, resulted in relatively short fire rotations, low species diversity, and short species longevity. Within the more xeric, sandy landforms, red pine likely has a maximum life expectancy of 150yrs and white pine around 250yrs.

Throughout the great lakes region northern pin-oak forests occur principally on sandy glacial outwash, sandy glacial land plains and less often on thin glacial frift over bedrock, inland dune ridges, and coarse-textured end moraines. Soils are typically coarse- to medium- textured sand or loamy sand and are moderately to extremely acidic with a surface layer or more humus from accumulated pine needles (Cohen 2002). Because this Biophysical Setting occurs on such a wide range of habitat types and has a wide variation of historic fire occurrence, this particular model relates to the dry to dry-mesic habitat types.

Vegetation Description

Upper canopy consists primarily of red pine (Pinus resinosa) and white pine (Pinus strobus). White pine

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was somewhat more abundant on more mesic, loamier soils, whereas red pine was more dominant on sandier soils (Schulte et al. 2002). Jack pine (Pinus banksiana) was generally restricted to sandier soils near established seed sources (Subsection 212Ka), where
stand-replacing fires were more frequent. Quaking aspen (Populus tremuloides), bigtooth aspen (Populus grandidentata), and paper birch (Betula papyrifera) were present and could be locally abundant in the early
successional classes (Schulte et al. 2002). Northern red oak (Quercus rubra), northern pin oak (Quercus ellipsoidalis), red maple (Acer rubrum), and balsam fir (Abies balsamea) were present in the mid to late successional classes; however, maple and fire were likely uncommon historically due to mortality from surface fires. Some evidence suggests that oak was a very minor component of this BpS historically (Dave Cleland, pers comm.).

Both red pine and white pine are fire-adapted species, though Frelich notes that white pine is less fire adapted ("can't live with fire, can't live without fire", Frelich 2002). From approximately 50yrs of age and older they can withstand surface fire quite well (Reference comments below which references a current fire history study being conducted on the Menominee Reservation).

The ground layer in this BpS consists of 25-75% forbs and graminoids. The most common vascular plats are Canada mayflower (Maianthemim canadense), wild sasparilla (Aralia macrophyllus), wintergreen (Gaultheria procumbens) and braken (Pteridium aquilinum).

The shrub layer is typically dominated by deciduous species such as lowbush blueberry (Vaccinium angustifolium), june berries (Amelanchier spp.) and red maple seedlings (Acer rubum).

Disturbance Description

This model pertains to those red and white pine systems that were historically maintained by frequent surface fires (as frequent as 5-10yrs, but more typically every 30yrs (Frelich 1999, online resource) and crown-fire rotations between 150-300yrs. Anthropogenic (human caused) fires was the most significant disturbance in this cover type and fire suppression has drastically changed the structure of these forest cover types. This type of fire that occurred prior to European settlement was very culturally connected (burning for berry gathering, hunting, to maintain travel routes, warfare, pest control, etc). Young white and red pines are generally killed by surface fires, but mature white and red pines (age 50-100yrs) become more resistant to fire disturbance due to development of thick bark that protects the cambium. Red pine develops thicker bark than white pine, and is considered more resistant to surface fire.

Forests of both species are less susceptible to stand-replacing fires when trees are mature, due to tall crowns and the wide spacing of dominant trees that is maintained by surface fires. However, when catastrophic crown fires do occur, mortality is high in all structural layers, and survivorship depends on random variations in fire patterns resulting in unburned areas.

Fire rotation is best exemplified by Fire Regime Group III, with fires occurring every 50yrs and low to moderate intensity surface fires most common. High intensity crown fires occur on approximately 290yr rotations. Severe wind events affect mature stands on an approximate 500-1000yr interval. During fire-free periods or periods with long surface fire rotation, mid-tolerant white pines gain dominance through gap-phase regeneration.

Heinselman (1981) suggested there are two types of red-white pine systems: those maintained by frequent surface fires and crown-fire rotation less than 150yrs, and those maintained by less frequent surface fires

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and crown-fire rotations between 150-300yrs. In the former, even-aged stands dominate, whereas in the latter, multi-aged white pine systems develop.

This description applies to red-white pine communities occurring within landscape ecosystems with properties resulting in long (150-300yr) stand-replacing fire rotations. Surface and crown fire regimes historically interacted to regulate age, landscape, within-stand structure, and succession within this community. Natural fuel breaks imposed by high lake and wetland densities inhibited fire spread within the landscapes this community dominated, resulting in a relatively long fire rotation of 250yrs. In northwestern Quebec, Dansereau and Bergeron (1993) similarly found that a large, homogeneous landscape, devoid of lakes, had larger fires and fires of greater intensity compared with a landscape containing numerous water bodies and rough topography. Bergeron (1991) also documented similar traits for mainland versus islands in a large lake.

Fire probability often increased with stand age due to the general increase in fuel (Clark 1990; Heinselman 1973), but individual tree susceptibility to damage or mortality from fire often declined with tree size due to increasing bark thickness and a separation of foliage from the ground, which reduces crown-fire occurrence. This community may have promoted surface fires by forming a deep, well-aerated litter layer of pine needles (McCune 1988). Relatively infrequent surface fires (30-50yrs) reduced fuel loadings, eliminated living fuel ladders, and promoted widely-spaced trees that became increasingly resistant to crown fires. Surface fires also reduced competition and succession to more shade-tolerant species.

Adjacency or Identification Concerns

Fire suppression, logging practices, exotics invasives all have influenced the current landscape conditions. Historic natural disturbance (fire) has been removed allowing for succession to late seral conditions. Harvesting practices have in some instances mimicked natural wind disturbance but not on the appropriate scale and frequency as historically. The exclusion of fire in this process is probably the key missing agent of successional change.

Native Uncharacteristic Conditions

Due to fire suppression and other human activities, oaks and the other fire dependant species within this BpS are declining, and are being replaced by other less fire adapted species such as red maple (Acer rubrum).

Stands heavily dominated by red maple or balsam fir in the canopy should be considered uncharacteristic in this BpS, as they would have been readily removed or reduced to lower canopy strata by relatively frequent surface fire.

Scale Description

Landscape must be adequate in size to contain natural variation in vegetation and disturbance regime. Though the virgin stands of red and white pine are greatly reduced from pre-settlement conditions, scattered stands and ecosystems still exist to represent this type. The Boundary Waters Canoe Area Wilderness (BWCAW) is an example, along with the national forests in MN (Chippewa, Superior), MI (Ottawa, Hiawatha) and WI (Chequamegon, Nicolet), and Menominee Reservation in WI.

Historical fire size ranged from small acreages (<1000ac) to extremely large events (>100,000ac or 40,000ha) (Heinselman, 1978). To capture a range of ecologically significant fire events, the following values were used: Minimum = 1000ac, maximum = 100,000ac, with an average of 10,000ac.

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Issues/Problems

Much of this type was heavily altered during landscape-scale historical harvesting in the late 1800s and early 1900s (Mladenoff & Pastor 1993). Many stands were burned multiple times following harvest. Aspen and birch became especially prevalent immediately following this period. Fire suppression and high-grading of remaining pine stands has exacerbated the trend away from pine and toward mid and later successional species such as red maple and balsam fir.

Plantations of red pine were established on this BpS in the 1930s by the CCC.

White pine blister rust, a potentially destructive fungal infection, was introduced to the US in the early 1900s, and caused relatively little white pine to be planted in this BpS throughout the latter half of this century. Red pine was preferentially planted instead, even though white pine would have been more historically dominant for some sites.

Comments

NOTE 5/20/08: As a result of final QC for LANDFIRE National by Jennifer Long the upper layer lifeform in class A was changed from "Shrub" to "Tree" because 1) according to LANDFIRE National rules the upper-layer lifeform should match the lifeform of height class which was "tree," 2) the class description described a regeneration phase of aspen, paper birch, red pine, white pine and oak and 3) the box noting the "upper layer lifeform was not dominant" was checked and the comment as follows, "dominant life form consists of low shrubs, ferns and herbaceous species although any existing scattered trees would be the upper level life form."

Additional comments provided by Brendan Ward (bward@fs.fed.us).

During an s-class call, it was noted that for this and other systems, the fact that there is more aspen on the landscape today than in the reference condition may not be captured by LANDFIRE methods, leading to a reduction in FRCC.

This model was adapted from 501362-2 by Jeremy Bennet and Ron Waukau to capture MN. 501362-2 was adapted from LANDFIRE Model 5113620 Laurentian-Acadian Northern Pine-(Oak) Forest by Becky Schillo (schillor@michigan.gov), Brad Slaughter (slaughterb@michigan.gov) and Doug Cox (mteecology@frontiernet.net). LANDFIRE Model 511362 built upon Rapid Assessment model R6RPWff - Red Pine White Pine with Frequent Fire by Tim Hepola (Tim_Hepola@fws.gov), Dave Cleland (dcleland@fs.fed.us) and Jim Merzenich (jmerzenich@fs.fed.us). The model was further refined to incorporate local data collected on the Menominee Reservation. (Jeremy Bennett, 3/21/07)

Comment related to Disturbance Description: A current fire history study being conducted on the Menominee Reservation has demonstrated that young pines (white and red pines as young as 10-15yrs of age) did survive surface fires that occurred in the mid 1800s. This contradicts the understanding that young pines will not survive surface fires until they reach a more mature age (50yrs+). This might suggest that these historic fires were very low intensity and burned in light flashy fuels. This suggests that the types of surface fire and the vegetation structure were very complex and variable. Much more information is needed to truly understand how to model these historic disturbances and reference conditions.

Doug Cox suggests Dan Pubanz (pubanz@frontiernet.net) as a potential reviewer for this system. (We concur. JB and RW). Also Tom Remus (mail364926@popnet.net).

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*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
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Vegetation Classes

Class A 28 %

Early Development 1 All Structure

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 2

Indicator Species* and Canopy Position

POTR5	Lower
BEPA	Lower
PIST	Lower
PIRE	Lower

Structure Data (for upper layer lifeform)

	Min	Max
Cover	11 %	40 %
Height	Tree 0m	Tree 5m
Tree Size Class	Pole 5-9" DBH	

☑ Upper layer lifeform differs from dominant lifeform.

Description

Dominant life form consists of low shrubs, ferns and herbaceous species although any existing scattered trees would be the upper level life form.

This class is a regeneration phase from either fire or wind. It consists mainly of aspen, paper birch, red pine, white pine and oak. It is typically a mixture of two pine species and three or more deciduous species. Where there is a lack of seeds or potential sucker trees, these areas can be initially colonized by red raspberry and blackberry (Rubus spp.), dogwood, red maple, cherry or other shrubs.

This class ranges from 0-55yrs. Replacement fire was modeled at every 200yrs, surface fires every 30yrs and wind every 750yrs, with all disturbances keeping this class in A.

Class B 20 %

Mid Development 1 Open

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 9

Indicator Species* and Canopy Position

PIST	Upper
PIRE	Upper
PIGL	Mid-Upper
POTR5	Upper

Structure Data (for upper layer lifeform)

	Min	Max
Cover	31 %	100 %
Height	Tree 5.1m	Tree 25m
Tree Size Class	Medium 9-21"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

This 55-75yr old class is a transition class marked by declines in jack pine, paper birch and aspen. Dominated by red pine, white pine and white spruce.

Replacement fire was modeled at every 200yrs, surface fires every 30yrs and wind every 750yrs. Wind and replacement fires would reset the system to class A and surface fires would maintain this class in class B.

Class C 29 %

Mid Development 2 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 2

Indicator Species* and Canopy Position

PIST	Upper
PIRE	Upper
PIGL	Mid-Upper
PIST	Lower

Structure Data (for upper layer lifeform)

	Min	Max
Cover	61 %	90 %
Height	Tree 5.1m	Tree 25m
Tree Size Class	Medium 9-21"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

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This 76-115yr old class is mature woodlands dominated by red pine, white pine and white spruce. Oaks may be present-present in modern mature woodlands of this type, but not mentioned in historic records (MNDNR 2003).

Replacement fire was modeled at every 200yrs, surface fires every 30yrs and wind every 750yrs. Wind and replacement fires would reset the system to class A and surface fires would move this class back to B (Frelich, 2000, online resource).

Class D **23 %**

Late Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 9

Indicator Species* and Canopy Position

PIST	Upper
PIRE	Upper
PIGL	Upper
VIAC	Lower

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	61 %	90 %
Height	Tree 25.1m	Tree 50m
Tree Size Class	Very Large >33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

This 116-999yr old class is mature woodlands dominated by red pine, white pine and white spruce with some white pines in understory of more open stands. Oaks may be present-present in modern mature woodlands of this type, but not mentioned in historic records (MNDNR 2003).

Replacement fire was modeled at every 200yrs, surface fires every 30yrs and wind every 750yrs. Wind and replacement fires would reset the system to class A and surface fires would move this class back to C (Frelich, 2000, online resource).

Class E **0 %**

[Not Used] [Not Used]

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☐ Tree

Fuel Model

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	%	%
Height		
Tree Size Class		

☐ Upper layer lifeform differs from dominant lifeform.

Description

Disturbances

Fire Regime Group:** I

Historical Fire Size (acres)

Avg 10000
Min 1000
Max 100000

Sources of Fire Regime Data

- ☑ Literature
- ☑ Local Data
- ☑ Expert Estimate

Fire Intervals

	Avg FI	*Min FI*	*Max FI*	*Probability*	*Percent of All Fires*
Replacement	200			0.005	13
Mixed	123.5			0.0081	22
Surface	40.82			0.0245	65
All Fires	27			0.0376	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inver of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

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Additional Disturbances Modeled

☐ Insects/Disease	☐ Native Grazing	☐ Other (optional 1)
☑ Wind/Weather/Stress	☐ Competition	☐ Other (optional 2)

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LANDFIRE Biophysical Setting Model

Biophysical Setting 5013622 Laurentian-Acadian Northern Pine Forest

☐ *This BPS is lumped with:*

☑ *This BPS is split into multiple models:* *There are two related BpSs described for MZ41. The first is described for the Lake Superior uplands border lakes region of MN section 212L. Soils here are shallow over bedrock. Oak is not an important component. The 2nd model is for the sand outwash plains in north central MN (section 212N) - BpS 1362-2 that includes oaks*

General Information

Contributors (also see the Comments field **Date**

Modeler 1	Randy Swaty	rswaty@tnc.org	**Reviewer**	Brian Palik	bpalik@fs.fed.us
Modeler 2			**Reviewer**	Mark White	Mark_White@tnc.org
Modeler 3			**Reviewer**	Dave Cleland	dcleland@fs.fed.us

Vegetation Type

Forest and Woodland

Map Zone

50

Model Zone

☐ Alaska ☐ N-Cent.Rockies
☐ California ☐ Pacific Northwest
☐ Great Basin ☐ South Central
☑ Great Lakes ☐ Southeast
☐ Northeast ☐ S. Appalachians
☐ Northern Plains ☐ Southwest

Dominant Species*

PIRE ABBA
PIST VAAN
BEPA
POTR5

General Model Sources

☐ Literature
☐ Local Data
☐ Expert Estimate

Geographic Range

The red pine (Pinus resinosa), white pine (Pinus strobus) cover type is found throughout the Great Lakes region including northern MN, WI and MI. The red–white pine community described here is for MZ41 and historically occured mainly in subsection 212La but also in 212Lb, c, d and e.

Biophysical Site Description

The area is on part of the Laurentian Peneplain and is geologically complex. It is underlain with pre-cambrian rock mainly granite, greenstones and slates. Soils were the type occurs are shallow generally less than 48in composed of sandy gravelly loams and till (Heinselman 1996, Ohmann and Ream 1971). The region is scattered with lakes which serve as fire breaks protecting these stands from the frequent high intensity fire regime characteristic of region. This type is therefore commonly found on islands and along the north, east and southeast shores of lakes, streams and wetlands where they are protected from severe fires commonly approaching from the southwest (Heinselman 1973, Swain 1973). Stands in this region can persist for 400 to 500yrs without fire, however pine overstory will be highly degraded at this point (Heinselman 1973).

Vegetation Description

Red pine often shares dominance with white pine in the overstory. Red pine being more dominant on the drier sites. Common understory trees species include red maple, red oak, paper birch and jack pine. Balsam fir, white and black spruce and white cedar may also be present. The tall shrub layer is not normally abundant with beaked hazel, green alder and juneberry being the most common. The ground

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vegetation is often sparse, dominated by blueberry, sweet fern (Comptonia peregrina), large-leafed aster and wild sarsaparilla (Aralia nudicaulis). Less abundant are bearberry (Arctostaphylos uva-ursi), wintergreen and pipsissewa. Mosses and lichens can cover 50% of the surface and include broom mosses, Schreber's moss, reindeer moss and lichens (Rudolf 1990, Ohmann and Ream 1971).

Stands are multi-aged, with at least two cohorts. Historically there was often a supercanopy pine cohort followed by a younger more abundant pine cohort. Due to variation in fire severity there are small to medium scales inclusions of different cohorts within large stands (Heinselman 1996, Van Wagner 1971).

Disturbance Description

The fire regime is characterized by frequent surface fires and infrequent crown fires with red pine stands burning more frequently than white pine. Observations of fire frequency for low severity surface fires by Heinselman (1973) ranged of 5-100yrs. The average frequency for red pine is in the range of 10-40yrs (Heinselman 1973, Frissell 1973) . The lower bound frequency for white pine is slightly longer with a range of 20-40yrs. These periodic surface fires can perpetuate the stand indefinitely, barring others disturbances such as logging or windthrow. Additionally, these fires will thin pine sapling which need 30-50yrs to develop fire resistant bark (Heinselman 1996). Stand replacement fires occur every 150-200yrs and 200-250yrs for red and white pine respectively.

Adjacency or Identification Concerns

Due to the complexity of the landform adjacent types can include any type common to the region. However most common adjacent types include jack pine, aspen, birch and fir (mixedwood).

As seen today the shrub/hardwood understory of this type is much denser than was common historically due to fire suppression.

Some sites were converted to aspen birch after logging. This occurred on the more mesic sites where the initial condition had a high component of aspen and birch.

Much of this type was heavily altered during landscape-scale historical harvesting in the late 1800s and early 1900s (Mladenoff and Pastor 1993)

Native Uncharacteristic Conditions

Scale Description

Landscape must be adequate in size to contain natural variation in vegetation and disturbance regime. Though the virgin stands of red and white pine are greatly reduced from pre-settlement conditions, scattered stands and ecosystems still exist to represent this type. The Boundary Waters Canoe Area Wilderness (BWCAW) is an example, along with the national forests in MN (Chippewa, Superior), MI (Ottawa, Hiawatha), and WI (Chequamegon, Nicolet), and Menominee Reservation in WI.

Issues/Problems

The VDDT model was modified to increase the probability of wind storm events. Frelich has documented wind disturbance of catastrophic proportions as occurring on a 1000-2000yr interval. Granted that this may possibly be the landscape level mean, wind events are far more prevalent and occur randomly and with widespread regularity throughout the range of the red and white pine cover type.

Comments

Additional comments provided by Brendan Ward (bward@fs.fed.us). This model adapted from

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LANDFIRE Model 5113620 Laurentian-Acadian Northern Pine-(Oak) Forest by Becky Schillo (schillor@michigan.gov), Brad Slaughter (slaughterb@michigan.gov) and Doug Cox (mteecology@frontiernet.net). LANDFIRE Model 511362 built upon Rapid Assessment model R6RPWff - Red Pine White Pine with Frequent Fire by Tim Hepola (Tim_Hepola@fws.gov), Dave Cleland (dcleland@fs.fed.us) and Jim Merzenich (jmerzenich@fs.fed.us).

Successional stages were adapted from Rapid Assessment model 1362 option 4 by Eric Henderson.

Lee Frelich (U of MN), Mark White (TNC, Duluth, MN) and Meredith Corenett (TNC Duluth, MN) are recommended as potential reviewers for this system.

Vegetation Classes

Class A 16 %

Early Development 1 All Structure

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 8

Indicator Species* and Canopy Position

PIRE	Upper
PIST	Upper
PIBA2	Upper
BEPA	Upper

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	80 %
Height	Tree 0m	Tree 10m
Tree Size Class	Pole 5-9" DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

This class is a regeneration phase following a stand replacing fire or wind disturbance. A nearby seed source is assumed that regenerates the site to red/white pine. It consists mainly of red pine, white pine, jack pine, paper birch, aspen and red maple. It is typically dominated by red and white pine with lesser amounts of other species.

This class ranges from 0-35yrs. Class A succeeds to class B.

Class B 18 %

Mid Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 8

Indicator Species* and Canopy Position

PIRE	Upper
PIST	Upper
BEPA	Mid-Upper
ABBA	Low-Mid

Structure Data (for upper layer lifeform)

	Min	Max
Cover	51 %	70 %
Height	Tree 10.1m	Tree 25m
Tree Size Class	Pole 5-9" DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

This stage also includes scattered paper birch, jack pine, balsam fir, red maple and occasionally oak. In this stage red and white pine dominate and overtop the hardwoods and fir. Black and white spruce become more common.

Age range is 36-75yrs old. Class B succeeds to class C. Surface fire, modeled with the probability of occurring every 33yrs will maintain the system in this class by removing the shade tolerant conifers and red maple.

Replacement fire would set the system back to class a with a fire return interval of 150yrs.

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Class C 16 %

Mid Development 2 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 8

Indicator Species* and Canopy Position

PIRE	Upper
PIST	Upper
ABBA	Mid-Upper
	Middle

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	51 %	80 %
Height	Tree 25.1m	Tree 50m
Tree Size Class	Medium 9-21"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Without fire balsam fir increases in density as do birch and maple and form a sporadic midstory. What aspen was present initially begins to drop out due to windthrow. Red and white pine continue to dominant the upper canopy.

Age 76 - 120yrs. Multi-layered canopy with trees less than 25m. Shrub component is well established. Class C succeeds to class D. Surface fire, modeled with the probability of occurring every 33yrs will maintain the system in this class, by thinning or removing shade tolerant conifers and red maple.

Class D 19 %

Late Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 8

Indicator Species* and Canopy Position

PIRE	Upper
PIST	Upper
ABBA	Mid-Upper
BEPA	Middle

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	81 %	90 %
Height	Tree 25.1m	Tree 50m
Tree Size Class	Large 21-33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Some overstory pines begin to succumb to windthrow (modeled as wind/weather/stress, probability 0.001). The understory of balsam fir and/or shrubs and hardwoods becomes quite dense. Openings in the canopy are filled with balsam, spruce and birch. Northern white cedar establishes on some sites.

Ages 121-200yrs. Surface fires, modeled with a probability of occurring every 33yrs, maintain the system in this class but revert the stand to an understory structure which is similar to class C.

Overstory remains the same with some holes burned in the canopy. Replacement fires can also occur in this class, modeled with the probability of occurring every 150yrs, will return the system to class A. Windthrow was modeled as wind/weather/stress with the probability of occurring every 1000yrs will revert the system to class B.

Class E 31 %

Late Development 2 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 8

Indicator Species* and Canopy Position

PIRE	Upper
PIST	Upper
ABBA	Mid-Upper
PIAL	Mid-Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	91 %	100 %
Height	Tree 10.1m	Tree 50m
Tree Size Class	Very Large >33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

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Description

Many overstory pines succumb to windthrow. Windthrow, modeled with a probability of occurring every 1000yrs, could maintain the system in this class or take it to class B or A depending on advanced regeneration. Remaining trees are supercanopy trees. Gaps are filled with birch, balsam, cedar, spruce, maple and brush. Site will soon be replaced by these species. Ages 200yrs+

Surface fires maintain the system, with a return interval of 33yrs. Overstory remains the same with some holes burned in the canopy.

Stand replacement fire, modeled with a probability of occurring every 200yrs.

Severe windthrow converts system to A if periodic surface fires were prevalent in the past and produced advanced regeneration. Otherwise system succeeds to Birch/Spruce/Fir/Cedar.

Disturbances

Fire Regime Group:** III

Historical Fire Size (acres)

Avg 0
Min 0
Max 0

Sources of Fire Regime Data

- [x] Literature
- [x] Local Data
- [x] Expert Estimate

Fire Intervals	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	2380			0.00042	2
Mixed					
Surface	39.37			0.0254	98
All Fires	39			0.02583	

Fire Intervals (FI):
Fire interval is expressed in years for each fire severity class and for all types of fir combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inver of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- [ ] Insects/Disease
- [x] Wind/Weather/Stress
- [ ] Native Grazing
- [ ] Competition
- [ ] Other (optional 1)
- [ ] Other (optional 2)

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100-year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement seve

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*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100-year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement seve

LANDFIRE Biophysical Setting Model

Biophysical Setting 5013651 Boreal White Spruce-Fir-Hardwood Forest - Inland

☑ *This BPS is lumped with: 1301*

☑ *This BPS is split into multiple models: This BpS (Boreal White Spruce-Fir-Hardwood Forest) has been split into a Great Lakes coastal system and an inland system. We describe the inland system here. The split is based on a difference in return interval of catastrophic fire with more frequent fires in inland systems and less frequent fires along the Great Lakes shoreline.*

General Information

Contributors (also see the Comments field **Date** 3/22/2007

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Modeler 2			**Reviewer**		
Modeler 3			**Reviewer**		

Vegetation Type

Forest and Woodland

Map Zone

50

Model Zone

☐ Alaska ☐ N-Cent.Rockies
☐ California ☐ Pacific Northwest
☐ Great Basin ☐ South Central
☑ Great Lakes ☐ Southeast
☐ Northeast ☐ S. Appalachians
☐ Northern Plains ☐ Southwest

Dominant Species*

ABBA POTR5
PIGL PIST
THOC2 TSCA
BEPA

General Model Sources

☑ Literature
☑ Local Data
☑ Expert Estimate

Geographic Range

Boreal forest is a circumboreal formation that has existed as a dominant assemblage in the northern Great Lakes region of the US and Canada for approximately 5-10,000yrs , following the retreat of the glaciers. Within North American, boreal forest is primarily found throughout Canada, ranging into AK. Within the Lake states and Ontario province, boreal forest is found in central Ontario, throughout northern MN, along the tip of the Door Peninsula in Lake Michigan and along the Lake Superior shoreline in WI, and within northern MI. The Boreal White Spruce-Fir-Hardwood Forest-Inland type is predominantly found beyond one kilometer of the Great Lakes shorelines. This is due primarily to the lack of lake effect variables; less frequently boreal forest occurs in localized inland areas of MI. Interpretation of notes of the general land surveyors indicate that circa 1800, boreal forest primarily occurred in the northern Lower Peninsula in Alpena, Cheboygan, Charlevoix and Emmet Counties and in the Upper Peninsula, boreal forest was concentrated in Keweenaw, Chippewa, Ontonogan, Delta and Mackinac Counties. Inland boreal forest occurs in the northern Lower Peninsula in section 212H and subsubsections 212Hi and 212Hj and throughout the Upper Peninsula in all sections and subsections. (Nichols 1935, Curtis 1959, Maycock and Curtis 1960, Stearns et al. 1982, Comer et al. 1995, Flakne 2003). System occurs in north central MN and the arrowhead region with deep, nutrient-rich, fine-textured soils.

Biophysical Site Description

Boreal forests occur primarily on sand dunes, in glacial lakeplains, and on thin soil over bedrock, both

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igneous and calcareous (e.g., limestone and dolomite cobble or pavement). Inland Boreal White Spruce-Fir-Hardwood Forest of the Great Lakes are typically found on moderately drained lakeplain and outwash deposits. Within lakeplain, boreal forest is often found in areas with poorly expressed dune and swale topography. Topography of these systems is typically flat to gently sloping.
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 found. Boreal forests that occur over limestone bedrock or cobble often are characterized by shallow organic soils or mull humus. Conifer dominance in the canopy results in a litter layer that 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 drained lakeplain or outwash (Curtis 1959, Comer et al. 1995, Stearns et al. 1982).

In Minnesota boreal forest occurs on soils that are deeper or finer-textured than soils in the jack pine forest that allowed development of dense forests of mixed aspen, birch, balsam fir, white spruce and red maple (Augustine and Frelich, 1998). This community occurs in upland positions, often with loamy shallow soils within bedrock-controlled landforms (Heinselman 1996).

Vegetation Description

Dominated by Abies balsamea, Picea glauca and Thuja occidentalis with Betula papyrifera and Populus tremuloides, shifting toward Betula and Populus following fire events, and towards conifers in the absence of fire. Thuja occidentalis dominance is most prevalent in sand dunes and on thin soils over neutral-alkaline bedrock or glacial deposits, such as in the Straits of Mackinac and in northeastern Lower Peninsula (Comer et al. 1995). White spruce is more prevalent on drier sites while balsam fir is more common on wetter sites (Curtis 1959). Additional canopy associates include Pinus strobus, Populus balsamifera and Tsuga canadensis and less frequently Picea mariana, Pinus resinosa, Pinus banksiana and Acer rubrum. In contrast to coastal boreal forests, inland systems are often characterized by an increased canopy component of Pinus strobus and Tsuga canadensis and deciduous species as the result of more frequent fire disturbance (Curtis 1959, Comer et al. 1995). Acer spicatum, A. pennsylvanicum, Sorbus americana and S. decorus are characteristic of the subcanopy and understory. Where Populus and/or Betula dominate the canopy, conifers are prevalent in the subcanopy and understory. Additional understory or tall shrub species include Cornus rugosa, Alnus rugosa and Sheperdia canadensis. Characteristic low shrubs include Lonicera canadensis, Arctostaphylos uva-ursi, Taxus canadensis, Ribes cynosbati, Vaccinium myrtilloides, Diervilla lonicera, Juniperus communis and Rubus pubescens. Groundlayer species are a mix of species found in mesic northern forest and northern swamp types, but prominent among them are Actaea rubra, Aralia nudicaulis, Aster macrophyllus, Carex eburnea, C. deweyana, Clintonia borealis, Coptis trifolia, Cornus candensis, Drypoteris spp., Galium triflorum, Goodyera spp. (i.e., G. oblongifolia and G. repens), Linnaea borealis, Mainthemum canadense, Mitella nuda, Mitchella repens, Pteridium aquilinum, Polygala paucifolia, Smilacina stellata, Streptopus roseus, Trientalis borealis and Viola spp.. Cypripedium arietinum and Iris lacustris are uncommon, but characteristic. Sphagnum species are common and can often form thick mats. Mosses and Usnea lichens often are abundant due to favorable, moist conditions. (Grant 1934, Darlington 1940, Potzger 1941, Buell and Niering 1957, Curtis 1959, Maycock and Curtis 1960, Buell and Martin 1961, Stearns et al. 1982, Harman and Plough 1986, Rutkowski and Stottlemyer 1993, MNFI Database).

Disturbance Description

Natural disturbance regime characterized by frequent windthrow and insect epidemics, which are typically small-scale events. Choristoneura fumiferana (Spruce budworm) defoliates both spruce and balsam fir but tends to be more detrimental to the latter (Curtis 1959). Outbreaks were typically localized resulting in

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patch scale disturbance effects. Interactions of blowdowns, insects, and climate (i.e., droughts) influence fire regimes of boreal forests. Infrequent catastrophic fires are an important disturbance factor (Curtis 1959), especially in inland boreal forests. Estimations for fire return interval for Canadian boreal forests range from 74-142yrs (Larsen and MacDonald 1998). During drought years the large quantities of Sphagnum moss and Usnea lichens can dry out and contribute significantly to fuel loadings. We estimate that the fire return interval for the inland boreal forests of Michigan probably ranged from 200-300yrs given that these systems occurred as patches in a matrix of a range of community types with varying fire regimes compared to the extensive, homogenous, flammable Canadian boreal forest. We also estimate that wind disturbance was more prevalent along the Great Lakes shoreline compared to inland systems. 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 (Curtis 1959, Maycock and Curtis 1960, Stearns et al. 1982, Comer et al. 1995).

Selective browsing by moose in the Upper Peninsula of Michigan (Isle Royale) 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 (Risenhoover and Maass 1987).

Adjacency or Identification Concerns

BpS adjacent to this system are 1302 (Laurentian-Acadian Northern Hardwoods Forest), 1344 (Boreal Jack Pine-Black Spruce Forest) and 1345 (Boreal White Spruce forest and Woodland).

This system can be confused with BpS 1345 (Boreal White Spruce Forest and Woodland).

Landscape scale spruce budworm (Choristoneura fumiferana) outbreaks that are a result of fire suppression and forest management practices would not have occurred under HRV. Encroachment in the form of conversion, urban sprawl and management practices such as forestry and fire suppression are effects that would not have impacted this system historically but occur in the present day. High levels of deer herbivory can result in regeneration failure of cedar.

With turn of the century forest management practices a second growth forest type is more dominant. Today this system is structurally less complex with less Canada yew and more abundance of balsam fir and white birch.

It is possible that the replanting efforts by the Civilian Conservation Core (CCC) in the 1930s have converted some of this system.

Mapped as Spruce-Fir-Cedar Forest on Comer et al.'s (1995) circa 1800 vegetation map. Corresponds to upland spruce-fir dominated current land cover.

Native Uncharacteristic Conditions

High levels of deer herbivory can result in regeneration failure of cedar.

Scale Description

Infrequent fires burned large areas (hundreds to thousands of acres), killing all or most overstory species. Small-scale outbreaks of spruce budworm likely occurred every 30-60yrs, killing primarily balsam fir over small scale (tens to hundreds of acres); occasional wind storms blew down trees over small scale (ten or more acres). The fire frequency or return interval was more frequent in this inland type than it's

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corresponding coastal type generally resulting in fires having greater geographic extent.

Issues/Problems

Need more research on spruce budworm impacts (what is scale and intensity of disturbance?). Disturbance return intervals (i.e., fire, wind and insect) for boreal forests are derived from Canadian systems and from research from MN. Estimations of fire size are based on polygon size of spruce-fir-cedar forest from circa 1800 vegetation map (Comer et al. 1995).

Comments

NOTE 5/20/08: As a result of final QC for LANDFIRE National by Jennifer Long the user-defined min and max fire return intervals for mixed severity fire were deleted because they were not consistent with the modeled fire return interval for this fire severity type.

This model adapted from the LANDFIRE Model 511365-2 Boreal White Spruce-Fir-Hardwood Forest-Great Lakes Inland by Joshua Cohen (cohenjo@michigan.gov) and Kimberly Hall (hallkim@msu.edu).

Model 511365-2 referred to related models derived by Donald Mikel and Barb Leuelling. Suggested reviewers: Dave Ewert, Bob Heyd, Deb McCollough, Dennis Albert, Eric Epstein, Donald Mikel, Barb Leuelling, Emmet J. Judziewicz and Eunice Padley.

Vegetation Classes

Class A 12 %

Early Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 8

Indicator Species* and Canopy Position

BEPA	Upper
POTR5	Upper

Structure Data (for upper layer lifeform)

	Min	Max
Cover	61 %	100 %
Height	Tree 0m	Tree 5m
Tree Size Class	Pole 5-9" DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

High density seedling-sapling-pole (0-30yrs) aspen-birch stand following stand-replacement fire event. Class A occurs following catastrophic fire which is assumed to occur at moderate fire frequency (200-300yrs) compared to coastal boreal forest systems. Low levels of conifer regeneration, which increase over time through seeding in. Catastrophic fire exposes mineral soil. Due to differences in growth rates birch and aspen initially dominate over spruce and fir. Class A succeeds to class C.

Class B 5 %

Early Development 2 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 8

Indicator Species* and Canopy Position

ABBA	Upper
PIGL	Upper
THOC2	Upper

Structure Data (for upper layer lifeform)

	Min	Max
Cover	61 %	100 %
Height	Tree 0m	Tree 5m
Tree Size Class	Pole 5-9" DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

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High density seedling-sapling-pole (0-30yrs) fir-spruce-cedar stand following catastrophic windthrow and moderate severity fire which leave adequate seed source to impart competitive advantage to conifers over early successional hardwoods. Infrequent catastrophic fire, modeled with the probability of occurring every 300yrs, can set class B to class A. Without fire, modeled as alternate succession at 70yrs, this class will succeed to class D.

Class C **15 %**

Mid Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 8

Indicator Species* and Canopy Position

BEPA	Upper
POTR5	Upper
ABBA	Low-Mid
PIGL	Low-Mid

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	71 %	90 %
Height	Tree 5.1m	Tree 10m
Tree Size Class	Medium 9-21"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Mature aspen-birch with spruce-fir-cedar understory development. Without fire, class A will succeed to class C and class C will succeed to class D. Infrequent catastrophic fire, modeled at the probability of occurring every 300yrs, can set class C to class A and infrequent windthrow, modeled at the probability of occurring every 1000yrs, will set class C to class B. Windthrow is expected to favor advanced regeneration of conifers while fire would favor aspen and birch.

Class D **68 %**

Late Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 8

Indicator Species* and Canopy Position

THOC2	Upper
PIGL	Upper
ABBA	Upper
PIST	

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	71 %	100 %
Height	Tree 10.1m	Tree 25m
Tree Size Class	Large 21-33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Spruce-fir-cedar forest with canopy associates including Pop tre, Bet pap, Pin str, Pop gra, Pin res, Pin ban, Pic mar and Tsu can. Following catastrophic fire (return interval 200-300yrs) class D goes to class A (early successional aspen-birch). Following catastrophic windthrow, modeled at the probability of occurring every 700-1000yrs, class D goes to class B (early successional spruce-fir-cedar). Mixed fire, modeled with the probability of occurring every 1000yrs (0.001), class D goes to class B. Spruce budworm, modeled at the probability of occurring every 33yrs, and small-scale windthrow events create small canopy gaps which maintain uneven-aged structure. Frequency of large-scale insect events needs further research.

Class E **0 %**

[Not Used] [Not Used]

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☐ Tree

Fuel Model

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	%	%
Height		
Tree Size Class		

☐ Upper layer lifeform differs from dominant lifeform.

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Description

Disturbances

Fire Regime Group:** V

Historical Fire Size (acres)

Avg 500
Min 100
Max 1000

Sources of Fire Regime Data

- [x] Literature
- [ ] Local Data
- [x] Expert Estimate

Fire Intervals	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	250	100	500	0.004	85
Mixed	1420			0.00070	15
Surface					
All Fires	213			0.00471	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inver of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- [x] Insects/Disease
- [x] Wind/Weather/Stress
- [ ] Native Grazing
- [ ] Competition
- [ ] Other (optional 1)
- [ ] Other (optional 2)

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LANDFIRE Biophysical Setting Model

Biophysical Setting 5013652 Boreal White Spruce-Fir-Hardwood Forest - Coastal

☐ *This BPS is lumped with:*

☑ *This BPS is split into multiple models:* *This BpS (Boreal White Spruce-Fir-Hardwood Forest) has been split into a Great Lakes coastal system and an inland system. We describe the coastal system here. The split is based on a difference in return interval of catastrophic fire with more frequent fires in inland systems and less frequent fires along the Great Lakes shoreline.*

General Information

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Modeler 2			**Reviewer**		
Modeler 3			**Reviewer**		

Vegetation Type

Forest and Woodland

Map Zone

50

Model Zone

☐ Alaska ☐ N-Cent.Rockies
☐ California ☐ Pacific Northwest
☐ Great Basin ☐ South Central
☑ Great Lakes ☐ Southeast
☐ Northeast ☐ S. Appalachians
☐ Northern Plains ☐ Southwest

Dominant Species*

THOC2 POTR5
PIGL
ABBA
BEPA

General Model Sources

☑ Literature
☑ Local Data
☑ Expert Estimate

Geographic Range

Boreal forest is a circumboreal formation that has existed as a dominant assemblage in the northern Great Lakes region of the US and Canada for approximately 5-10,000yrs , following the retreat of the glaciers. Within North America, boreal forest is primarily found throughout Canada, ranging into AK. Within the Lake states and Ontario province, boreal forest is found in central Ontario, throughout northern MN, along the tip of the Door Peninsula in Lake Michigan and along the Lake Superior shoreline in WI, and within northern MI. The Boreal White Spruce-Fir-Hardwood Forest-Coastal type is predominantly found within approximately one kilometer of the Great Lakes shorelines. This is due primarily to lake effect and can extend beyond the one kilometer range if there exists significant elevation which exhibit cooler and moister conditions. More specifically, within MI and WI this forest type is predominantly found on Great Lakes islands and along coastal areas. In MI it is also found along coastal areas of the northernmost portion of the Lower Peninsula and throughout the Upper Peninsula; less frequently boreal forest occurs in localized inland areas of the Upper Peninsula. Interpretation of notes of the general land surveyors indicate that circa 1800, boreal forest primarily occurred in the northern Lower Peninsula in Alpena, Cheboygan, Charlevoix and Emmet Counties and in the Upper Peninsula, boreal forest was concentrated in Keweenaw, Chippewa, Ontonogan, Delta and Mackinac Counties. Coastal boreal forest occurs in the northern Lower Peninsula in section 212H and subsubsections 212Hi, 212Hj, and 212Hf and throughout the Upper Peninsula in sections 212R, 212S, 212Y, 212J and subsections 212Rd, 212Re, 212Ra, 212Rc, 212Sc, 212Sq, 212Sn, 212Sb, 212Ya, and 212Jb along the Great Lakes shoreline. (Flakne 2003, Comer et

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al. 1995, Stearns et al. 1982, Maycock and Curtis 1960, Curtis 1959, Nichols 1935).

Biophysical Site Description

Boreal forest typically occupies upland sites (often with local wet places) along shores of the Great Lakes, on islands in the Great Lakes (e.g. Isle Royale, Apostle Islands, Drummond Island, Beaver Island) and locally inland (e.g. restricted areas in the Negaunee Michigamme Highlands). Coastal boreal forests occur primarily on sand dunes, in glacial lakeplains, and on thin soil over bedrock, both igneous and calcareous (e.g., limestone and dolomite cobble or pavement). Farther inland, moderately 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. Coastal boreal forests occurring along the mainland often form narrow, linear bands while archipelagic boreal forests often occupy broader areas of variable shape along the island shoreline, especially along the southwestern portion of the island (Harman and Plough 1986). Near shore boreal forests occupy peninsulas, former embayments, and coves. Topography of these systems ranges widely from gently sloping on lakeplain systems too steep topography on high dune fields, especially where Aeolian features have been deposited on moraines.

Proximity to the Great Lakes results in modified climate with cool, relatively equable temperature, short growing season, abundant available moisture during the growing season often in the form of fog or mist, and deep snows in the winter (Potzger 1941, Curtis 1959, Harman and Plough 1986). 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 found. Boreal forests that occur over limestone bedrock or cobble often are characterized by shallow organic soils or mull humus. Conifer dominance in the canopy results in a litter layer that 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 drained lakeplain or outwash (Curtis 1959, Comer et al. 1995, Stearns et al. 1982).

Vegetation Description

Dominated by Abies balsamea, Picea glauca and Thuja occidentalis with Betula papyrifera and Populus tremuloides, shifting toward Betula and Populus following fire events, and towards conifers in the absence of fire. Thuja occidentalis dominance is most prevalent in sand dunes and on thin soils over neutral-alkaline bedrock or glacial deposits, such as in the Straits of Mackinac and in the northeastern Lower Peninsula (Comer et al. 1995). White spruce is more prevalent on drier sites while balsam fir is more common on wetter sites (Curtis 1959). Additional canopy associates include Pinus strobus, Populus balsamifera and Tsuga canadensis and less frequently Picea mariana, Pinus resinosa, Pinus banksiana and Acer rubrum. In contrast to coastal boreal forests, inland systems are often characterized by an increased canopy component of Pinus strobus and Tsuga canadensis and deciduous species as the result of more frequent fire disturbance (Curtis 1959, Comer et al. 1995). Acer spicatum, A. pennsylvanicum, Sorbus americana and S. decorus are characteristic of the subcanopy and understory. Where Populus and/or Betula dominate the canopy, conifers are prevalent in the subcanopy and understory. Additional understory or tall shrub species include Cornus rugosa, Alnus rugosa, and Sheperdia canadensis. Characteristic low shrubs include Lonicera canadensis, Arctostaphylos uva-ursi, Ribes cynosbati, Vaccinium myrtilloides, Diervilla lonicera, Juniperus communis and Rubus pubescens. In some cases Taxus canadensis would have been quite dense in localized areas reducing diversity and occurrence of other groundlayer species. Groundlayer species are a mix of species found in mesic northern forest and northern swamp types, but prominent among them are Actaea rubra, Aralia nudicaulis, Aster macrophyllus, Carex eburnea, C. deweyana, Clintonia borealis, Coptis trifolia, Cornus candensis, Drypoteris spp., Galium triflorum, Goodyera spp. (i.e., G. oblongifolia and G. repens), Linnaea borealis,

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Mainthemum canadense, Mitella nuda, Mitchella repens, Pteridium aquilinum, Polygala paucifolia, Smilacina stellata, Streptopus roseus, Trientalis borealis, and Viola spp., Cypripedium arietinum and Iris lacustris are uncommon, but characteristic. Sphagnum species are common and can often form thick mats. Mosses and Usnea lichens often are abundant due to favorable, moist conditions. (Grant 1934, Darlington 1940, Potzger 1941, Buell and Niering 1957, Curtis 1959, Maycock and Curtis 1960, Buell and Martin 1961, Stearns et al. 1982, Harman and Plough 1986, Rutkowski and Stottlemyer 1993).

Disturbance Description

Proximity to the Great Lakes results in the moderation of the microclimate of coastal 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 (Curtis 1959, Potzger 1941). Natural disturbance regime characterized by frequent windthrow and insect epidemics, which are typically small-scale events. Because many sites lie next to the Great Lakes and trees are shallowly rooted, windthrow and snap-off rates are high (Comer et al. 1995, Curtis 1959, Grant 1934); balsam fir is especially susceptible to windthrow and breakage (Buell and Martin 1961). Choristoneura fumiferana (Spruce budworm) defoliates both spruce and balsam fir but tends to be more detrimental to the latter (Curtis 1959). Outbreaks were typically localized resulting in patch scale disturbance effects. Interactions of blowdowns, insects, and climate (i.e., droughts) influence fire regimes of boreal forests. Infrequent catastrophic fires are an important disturbance factor (Curtis 1959), especially in inland boreal forests. Estimations for fire return interval for Canadian boreal forests range from 74-142yrs (Larsen and MacDonald 1998). During drought years the large quantities of Sphagnum moss and Usnea lichens can dry out and contribute significantly to fuel loadings. Given the prevailing landscape position of most Great Lakes boreal forests (along the shoreline), the fire return interval for these systems was probably greater than 300yrs with fire return intervals more similar to Canadian forests for inland Great Lakes systems. 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 (Comer et al. 1995, Stearns et al. 1982, Maycock and Curtis 1960, Curtis 1959).

Selective browsing by moose in the Upper Peninsula of Michigan (Isle Royale) 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 (Risenhoover and Maass 1987).

Adjacency or Identification Concerns

BpS adjacent to this system are 1302 (Laurentian-Acadian Northern Hardwoods Forest), 1344 (Boreal Jack Pine-Black Spruce Forest) and 1345 (Boreal White Spruce forest and Woodland).

This system can be confused with BpS 1345 (Boreal White Spruce Forest and Woodland).

Landscape scale spruce budworm (Choristoneura fumiferana) outbreaks that are a result of fire suppression and forest management practices would not have occurred under HRV. Encroachment in the form of conversion, urban sprawl and management practices such as forestry and fire suppression are effects that would not have impacted this system historically but occur in the present day. High levels of deer herbivory can result in regeneration failure of cedar.

With turn of the century forest management practices a second growth forest type is more dominant. Today this system is structurally less complex with less Canada yew and more abundance of balsam fir and white birch.

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It is possible that the replanting efforts by the Civilian Conservation Core (CCC) in the 1930s have converted some of this system.

Along shorelines, boreal forest often shares an abrupt boundary with coastal communities such as cobble beach, sand/gravel beach, open dunes, limestone bedrock lakeshore, Great Lakes marsh, and Great Lakes barrens and gradually grades to mesic northern forest or less frequently rich conifer swamp, limestone bedrock glade, or alvar inland from the lakeshore. Mapped as Spruce-Fir-Cedar Forest on Comer et al.'s (1995) circa 1800 vegetation map. Coastal boreal forest are typically within 1000 meters of the shoreline and correspond to conifer dominated current land cover.

Native Uncharacteristic Conditions

Scale Description

Infrequent fires burned large areas (hundreds of acres), killing all or most overstory species. Small-scale outbreaks of spruce budworm likely occurred every 30-60yrs, killing primarily balsam fir over small scale (tens of acres); occasional wind storms blew down trees over small scale (ten or more acres).

Issues/Problems

Need more research on spruce budworm impacts (what is scale and intensity of disturbance?). Disturbance return intervals (i.e., fire, wind, insect) for boreal forests are derived from Canadian systems and from research from MN. Estimations of fire size are based on polygon size of spruce-fir-cedar forest from circa 1800 vegetation map (Comer et al. 1995).

Comments

This model adapted from the LANDFIRE Model 511365-1 Boreal White Spruce-Fir-Hardwood Forest-Great Lakes Coastal by Joshua Cohen (cohenjo@michigan.gov) and Kimberly Hall (hallkim@msu.edu). Model 511365-1 referred to related models derived by Donald Mikel and Barb Leuelling. Suggested reviewers: Dave Ewert, Bob Heyd, Deb McCollough, Dennis Albert, Eric Epstein, Donald Mikel, Barb Leuelling, Emmet J. Judziewicz and Eunice Padley.

Vegetation Classes

Class A 4 %

Early Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 8

Indicator Species* and Canopy Position

BEPA	Upper
POTR5	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	61 %	100 %
Height	Tree 0m	Tree 5m
Tree Size Class	Pole 5-9" DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

High density seedling-sapling-pole (0-30yrs) aspen-birch stand following stand-replacement fire event. Class A occurs following catastrophic fire which is assumed to occur at low fire frequency (500-1000yrs) compared to inland boreal forest systems. Low levels of conifer regeneration, which increase over time through seeding in. Catastrophic fire exposes mineral soil. Due to differences in growth rates birch and aspen initially dominate over spruce and fir. With time this class succeeds to class C.

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Class B 6 %

Early Development 2 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 8

Indicator Species* and Canopy Position

ABBA	Upper
PIGL	Upper
THOC2	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	61 %	100 %
Height	Tree 0m	Tree 5m
Tree Size Class	Pole 5-9" DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

High density seedling-sapling-pole (0-70yrs) fir-spruce-cedar stand following catastrophic windthrow and moderate severity fire which leave adequate seed source to impart competitive advantage to conifers over early successional hardwoods. Infrequent catastrophic fire, modeled with the probability of occurring every 500yrs, can set class B to class A. Without fire, modeled as alternate succession at 70yrs, this class will succeed to class D.

Class C 4 %

Mid Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 8

Indicator Species* and Canopy Position

BEPA	Upper
POTR5	Upper
ABBA	Low-Mid
PIGL	Low-Mid

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	71 %	100 %
Height	Tree 5.1m	Tree 10m
Tree Size Class	Medium 9-21"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Mature aspen-birch with spruce-fir-cedar understory development. Without fire, class A will succeed to class C and class C will succeed to class D. Infrequent catastrophic fire, modeled with the probability of occurring every 500yrs (0.002), can set class C to class A and infrequent windthrow, modeled with the probability of occurring every 1000yrs (0.001) will set class C to class B. Windthrow is expected to favor advanced regeneration of conifers while fire would favor aspen and birch.

Class D 86 %

Late Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 8

Indicator Species* and Canopy Position

THOC2	Upper
PIGL	Upper
ABBA	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	71 %	100 %
Height	Tree 10.1m	Tree 25m
Tree Size Class	Large 21-33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Spruce-fir-cedar forest with canopy associates including Pop tre, Bet pap, Pop gra, Pin str, Pin res, Pin ban, Pic mar and Tsu can. Following catastrophic fire (return interval 500-1000yrs) class D goes to class A (early successional aspen-birch). Following catastrophic windthrow, modeled with the probability of occurring every 1000yrs (0.001), class D goes to Class B (early successional spruce-fir-cedar). Mixed fire, modeled with the probability of occurring every 1000yrs (0.001), class D goes to class B. Spruce budworm, modeled with the probability of occurring every 60yrs (0.017), and small-scale windthrow events create small canopy gaps which maintain uneven-aged structure. Frequency of large-scale insect events needs further research.

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Class E **0 %**

[Not Used] [Not Used]

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☐ Tree

Fuel Model

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	%	%
Height		
Tree Size Class		

☐ Upper layer lifeform differs from dominant lifeform.

Description

Disturbances

Fire Regime Group:** **V**

Historical Fire Size (acres)

Avg 50
Min 1
Max 200

Sources of Fire Regime Data

- ☑ Literature
- ☐ Local Data
- ☑ Expert Estimate

Fire Intervals	*Avg FI*	*Min FI*	*Max FI*	*Probability*	*Percent of All Fires*
Replacement	909	300	1500	0.00110	58
Mixed	1250	300	1500	0.0008	42
Surface					
All Fires	526			0.00191	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fir combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inver of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- ☑ Insects/Disease
- ☑ Wind/Weather/Stress
- ☐ Native Grazing
- ☐ Competition
- ☐ Other (optional 1)
- ☐ Other (optional 2)

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100-year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement seve

LANDFIRE Biophysical Setting Model

***Biophysical Setting* 5013660** **Laurentian-Acadian Pine-Hemlock-Hardwood Forest**

☐ *This BPS is lumped with:*
☐ *This BPS is split into multiple models:*

General Information

Contributors (also see the Comments field **Date** 1/26/2005

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Modeler 3			**Reviewer**		

Vegetation Type
Forest and Woodland

Map Zone
50

Model Zone
☐ Alaska ☐ N-Cent.Rockies
☐ California ☐ Pacific Northwest
☐ Great Basin ☐ South Central
☑ Great Lakes ☐ Southeast
☐ Northeast ☐ S. Appalachians
☐ Northern Plains ☐ Southwest

Dominant Species*
PIST
TSCA
BEAL2

General Model Sources
☑ Literature
☑ Local Data
☑ Expert Estimate

Geographic Range

In MZ50, this system would have historically been present in sections 212X, 212T, 212J, 212Y, with occasional relict patches in 222Lc and 222Ld.

This type estimated to cover appoximately 2 million acres circa 1800 in MI, with heavy concentrations in the Saginaw Valley and Thumb regions in the Lower Peninsula, and extending northward through the Upper Peninsula. Beech-sugar maple-hemlock forests, which dominated nearly 17% of the state surface in the 1800s, were mostly found on large expanses of rolling moraines in the northern Lower Peninsula and eastern Upper Peninsula. This species mix was also found on the clay lake plain along Saginaw Bay.

Biophysical Site Description

Hemlock and white pine have wide ecological amplitudes, occurring with wetland conifers in poorly-drained landforms and with mesophilic northern hardwoods in marginal upland landforms. White pine and hemlock become dominant within mixed forests in upland ice-contact and glacial lakebed landforms of intermediate soil fertility. These landscape ecosystems typically have low proportions of sugar maple and associated mesophilic deciduous species due to limited soil nutrient availability or moisture holding capacity. Species adapted to frequent disturbance (e.g., jack pine, aspen) occur in low proportions.

Extreme podzolization can occur in relatively pure hemlock stands due to highly acidic hemlock needles (Curtis 1959). In MZ50, the distribution would be correlated with SSURGO map units with high percentages of Spodosols, especially Entic and Alfic Haplorthods, and occasionally on Oxyaquic Haplorthods

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Vegetation Description

In the mid-1800s, there were 2.2 million acres of white pine-hemlock ecosystems within the 10.6 million acres of forestlands in northern lower MI (Province 212; Cleland et al. 2004, ongoing R-9/SRS/MTU study). Based on analysis of GLO line tree observations, white pine–hemlock communities were dominated by "pine" recorded to the genus level, followed by hemlock, white pine, red pine and beech. It is likely much of the undifferentiated pine was white pine given the large diameters of this class (mean of 19.3 inches). Pine and hemlock comprised 62% of GLO line trees, mesophilic sugar maple 3%, and early successional oak, white birch and aspen 10%.

In the mid-1800s, there were 3.2 million acres of white pine-hemlock-birch ecosystems within the 17.8 million acres of forest lands in northern Wisconsin (Cleland et al. 2004a, ongoing R-9/SRS/MTU study). These landscape ecosystems were dominated by three communities identified by Schulte et al. (2002) as hemlock, hemlock–white pine, and hemlock–yellow birch. Pine and hemlock comprised 33% of GLO line trees, mesophilic sugar maple and yellow birch about 17%, and early successional oak, white birch and aspen about 20%. The white pine-hemlock forests of Wisconsin were more diverse than those of northern lower MI, with higher proportions of both early and late successional deciduous species. This may be due to the prevalence of wetlands and lakes within Wisconsin, which provided sheltered landscape positions favoring sugar maple, and poorly-drained soils favoring yellow and white birch and quaking aspen. Much of the white pine-hemlock BpS was in an old growth state, and relatively low densities of tall, large-diameter trees dominated the landscape. Old-growth white pine-hemlock stands were often partially multi-aged (Holla and Knowles 1988) or uneven-aged due to continuous recruitment caused by local disturbances (Quinby 1991). Rogers (1978) reported only 8% of the hemlock stands sampled from WI to Nova Scotia were even-aged, indicating that very few of the hemlock stands were initiated after a catastrophic event such as a wildfire. In a study of old growth white pine in Canada (Guyette and Dey 1995), canopy dominance and tree size suggested an even-aged structure, whereas actual ages of dominant trees ranged from 267-486yrs. White pine older than 400yrs made up 20% of the dominant trees, 52% were 300-400yrs old, and 28% were 250-300yrs old. White pine persisted as the dominant species over a seven-century period in an old-growth white pine forest of Canada, indicating that white pine was self-replacing (Quinby 1991).

Disturbance Description

The hemlock–white pine forests of northern lower MI and WI were disturbed by large-scale stand-replacing crown fires within rotations of 400–500yrs (Cleland et al. 2004a) and by wind events of comparable rotations. During the centuries between catastrophic disturbances, low-intensity small surface fires, windthrown trees and the death of large individual trees through biological or other agents interacted to regulate stand-scale gap dynamics.

The complex structure and age-class distribution of this ecosystem are due to these two distinct disturbance regimes. Broad-scale crown fires occurred very infrequently, selecting for pyrophilic species capable of reproducing in full-light conditions following stand-replacing disturbance. Fine-scale single or group tree mortality and blowdown occurred continuously, and selected for shade-tolerant and mid-shade-tolerant species.

Once white pine has matured and attained larger diameters and crown height, widely spaced dominants are highly resistant to intense surface or maintenance fires (Beverly and Martell 2003). Hemlock is injured or killed by surface fires due to its shallow root system, thin bark, and low branches (Carey 1993), and all species suffer high rates of mortality following crown fires. The successional dynamics of this ecosystem after mixed or severe crown fires may involve establishment of aspen, paper birch, red pine, or white pine

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immediately following the disturbance, with subsequent succession to white and red pine and red oak, followed by late
successional gap-phase invasion of hemlock and yellow birch beneath white pine during long fire-free periods (Davis et al. 1992)

Successional trajectories were historically regulated by disturbance regime, as well as by landscape-level patterns in communities and environment and localized edaphic conditions. Landscape-level patterns of lakes, wetlands, deciduous species, openlands, and other fuel discontinuities determined fire-exposed versus fire-protected landscape positions (Dovciak et al. 2003). Within landforms, localized conditions of soil texture and drainage, and resulting gradients of available nutrients and moisture impeded invasion by nutrient-demanding shade-tolerant hardwoods (Rogers 1978).

Preferential recruitment of hemlock beneath white pine and development of mor-like soil organic horizons within hemlock stands that inhibited hardwood invasion (Davis et al. 1994) are examples of biologically mediated successional dynamics. All these natural processes and factors have had a strong selective effect on the age, structure and composition of these forests.

Adjacency or Identification Concerns

This system is distinguished from other similar systems by a strong pine component and the potential to succeed to hemlock-dominated stands; this would have been possible under the natural disturbance regime and given natural densities of seed sources. Historical harvesting and subsequent repeated fires in the late 1800s and early 1900s have allowed some expansion of BpS 1302 (Laurentian-Acadian Northern Hardwood Forest) and BpS 1362-2 (Laurentian-Acadian Northern Pine-Oak Forest) onto sites formerly occupied by this type, particularly due to dramatic decreases in available hemlock seed sources. Expansion and comingling of 1302 would generally be restricted to more loamy and nutrient rich soils. Comingling with 1362-2 would occur primarily near sites with historically more frequent fire. Lack of hemlock seed sources and hemlock recruitment on the landscape would effectively convert this to 1362-2 during the later successional stages. Historical data sources will be required to correctly
depict the historic distribution of this type.

Native Uncharacteristic Conditions

Scale Description

Landscape must be adequate in size to contain natural variation in vegetation and disturbance regime. Replacement fires at 400-500yrs may be in the thousands of acres. Surface and mixed fires could be less than 10ac.

Issues/Problems

Much of this type was heavily altered during landscape-scale historical harvesting in the late 1800s and early 1900s (Mladenoff & Pastor 1993), primarily resulting in a drastic reduction of hemlock seed sources on the landscape. Current recruitment of hemlock may be limited not only by this reduced distribution of seed sources, but also from significant rates of browsing by white-tailed deer (Carey 1993).

Comments

For LANDFIRE-this modeled was modified from the Cleland, Merznich and Lucas Rapid Assessment model (R6WPHEif) based on new knowledge.

Notes from Rapid Assessment model: Edits from FRCC description document and model are insignificant. Corrected some minor errors in model with Jim Merzenich. This model has three early-successional

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classes and class A can succeed to either class B or C. Additional modelers: Kim Brosofske, Sari Saunders, Greg Nowacki, Bill Patterson, Andi Koonce.

Vegetation Classes

Class A 3 %

Early Development 1 All Structure

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 9

Indicator Species* and Canopy Position

BEPA	Upper
POTR5	Upper

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	100 %
Height	Tree 0m	Tree 5m
Tree Size Class	Seedling <4.5ft	

☐ Upper layer lifeform differs from dominant lifeform.

Shrubs can be dominant lifeform, 50-100% cover.

Description

Openings. 0-10yrs following a replacement event in classes A, B and C. Replacement fire is modeled at every 200yrs (0.005). This box succeds to class B.

Class B 16 %

Early Development 2 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 9

Indicator Species* and Canopy Position

QURU	Upper
BEPA	Upper
POTR5	Upper
ACRU	Upper

Structure Data (for upper layer lifeform)

	Min	Max
Cover	71 %	90 %
Height	Tree 5.1m	Tree 10m
Tree Size Class	Sapling >4.5ft; <5"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Post replacement regeneration with early seral species. 11-80yrs. Succeds to class C without the repalcement fires that were modeled at every 500yrs (0.002) and windthrow which was modeled at every 1000yrs (0.001). There is also a maintenance (surface) fire that occurs every 200yrs (0.005) keeping the class in B.

Balsam fir could occasionally become established during this class, but would have been primarily limited to the understory and midstory strata.

Class C 39 %

Mid Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 9

Indicator Species* and Canopy Position

PIST	Upper
PIRE	Upper

Structure Data (for upper layer lifeform)

	Min	Max
Cover	51 %	90 %
Height	Tree 5.1m	Tree 10m
Tree Size Class	Medium 9-21"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Stands consist of red pine and young white pine, generally and the box is aged 81-300yrs. There are four distrubances moded in this class: 1) mixed fire occuring every 400yrs (0.0025) maintaining class C, 2) replacement fire occuring every 500yrs transitioning to class A, 3) surface fire occuring every 250yrs keeping the cells in C and 4) windthrow which transitions cells to A.

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*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100-year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement seve

Without distrubance these cells transition to class D.

Class D 42 %

Late Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 9

Indicator Species* and Canopy Position

PIST	Upper
TSCA	Upper

Structure Data (for upper layer lifeform)

	Min	Max
Cover	51 %	100 %
Height	Tree 10.1m	Tree 50m
Tree Size Class	Very Large >33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Stands consist of mature and old growth white pine. Over time, and in fire's absence, associated large hemlock may develop. Replacement fire was modeled with a probability of 0.0020 with a transition to A, surface fire modeled at a probability of 0.0025 maintaining the class, and windthrow was modeled with a probability of 0.001 with a transition to class C.

Class E 0 %

[Not Used] [Not Used]

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☐ Tree

Fuel Model

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	Max
Cover	%	%
Height		
Tree Size Class		

☐ Upper layer lifeform differs from dominant lifeform.

Description

Disturbances

Fire Regime Group: III**

Historical Fire Size (acres)

Avg
Min 1
Max 2000

Sources of Fire Regime Data

- ☑ Literature
- ☑ Local Data
- ☑ Expert Estimate

Fire Intervals

	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	476.2			0.0021	37
Mixed	9090			0.00011	2
Surface	294.1			0.0034	61
All Fires	178			0.00561	

Fire Intervals (FI):
Fire interval is expressed in years for each fire severity class and for all types of fir combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inver of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- ☐ Insects/Disease
- ☑ Wind/Weather/Stress
- ☐ Native Grazing
- ☐ Competition
- ☐ Other (optional 1)
- ☐ Other (optional 2)

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100-year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement seve

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LANDFIRE Biophysical Setting Model

Biophysical Setting 5013940 North-Central Interior Oak Savanna

☐ *This BPS is lumped with:*
☐ *This BPS is split into multiple models:*

General Information

Contributors (also see the Comments field **Date** 3/7/2007

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Vegetation Type
Upland Savannah/Shrub Steppe

Map Zone
50

Model Zone
☐ Alaska ☐ N-Cent.Rockies
☐ California ☐ Pacific Northwest
☐ Great Basin ☐ South Central
☑ Great Lakes ☐ Southeast
☐ Northeast ☐ S. Appalachians
☐ Northern Plains ☐ Southwest

Dominant Species*

QUAL	CORYL
QUVE	SCHIZ4
QUMA2	SONU2
ANGE	CEAM

General Model Sources
☑ Literature
☑ Local Data
☑ Expert Estimate

Geographic Range

Northern oak savanna occurs in a complex, shifting mosaic with oak woodlands, barrens and prairies in the upper Midwest. This type occurs in southern lower MI, northwestern OH, northern IN, northeastern IL, southern WI and southeastern to northwestern MN. This savanna/woodland/prairie type historically occurred as an ecotone between mesic hardwood forest and tallgrass prairie.

This model represents the system in LANDFIRE MZs 41, 50 and 51. Within these mapzones north-central interior oak savanna occurs in sections 222J: b, h, k, I, g, e, r and 222U: e, a and 222m and 251b.

Biophysical Site Description

Northern oak savanna occurs primarily on level to rolling topography of glacial outwash plains, coarse-textured end moraines, and steep ice-contact features (Cohen 2004a, NatureServe 2004, Michigan Natural Features Inventory 2003, Cohen 2001, Albert 1995, Chapman 1984). Soils are well-drained, moderately-fertile sands, loamy sands, sandy loams, and loams with medium-acid to neutral pH (5.6 to 7.3) and low water retaining capacity (NatureServe 2004, Michigan Natural Features Inventory 2003, Chapman 1984). In general, oak savannas are most prevalent on the western side of major firebreaks such as rivers (Leitner et al. 1991, Grimm 1984, Curtis 1959). In the 1800s, oak savanna communities covered some 11 to 13 million ha (27 to 32 million ac) of the Midwest (Nuzzo 1986).

Vegetation Description

Today, northern oak savanna in the upper Midwest is limited to small, degraded remnants. As a result, little is known about the original composition and vegetative patterning of these systems (Leach and Givnish 1999). Information in this section is derived from historical accounts, early plant collections, and extrapolation based on remnants within Midwestern states. The oak openings were described by Michigan

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settlers as park-like savanna of widely spaced mature oaks with a wide range of shrub cover above the forb and graminoid ground layer (Chapman 1984, Peters 1970, Cottam 1949, Stout 1946). The community was composed of broad-crowned, scattered oaks with a graminoid ground layer composed of species associated with both prairie and forest communities.

The canopy layer generally varied from 10 to 60% cover (NatureServe 2004) and was dominated by Quercus alba (white oak) with co-dominants including Q. macrocarpa (bur oak) especially in the west, and Q. velutina (black oak) (NatureServe 2004, Chapman 1984, Cottam 1949). White oak, black oak, and bur oak with their thick bark, deep roots, and resprouting abilities are the most fire-resistant of the oaks. In addition, expansive root systems that can extend down several meters and branch extensively laterally allow these oaks to withstand extreme drought stress (Faber-Langendoen and Tester 1993, Abrams 1992, Albertson and Weaver 1945). These species of oak are long-lived, often remaining as canopy dominants for 200-300yrs (Cottam 1949). Important canopy associates include, Carya ovata (shagbark hickory), Quercus rubra (red oak), and Quercus velutina (black oak) and in Michigan, Carya glabra (pignut hickory) (NatureServe 2004). Oaks, especially black oak, are dispersed in the understory as fire-suppressed grubs which reach just over a meter tall (Anderson and Bowles 1999, Bowles and McBride 1998, Brewer and Kitler 1989, Peters 1970). Shrubs occur scattered or clumped in the understory, ranging widely in cover from 0-50% depending on fire frequency (Pruka and Faber-Langendoen 1995). The most common shrubs are fire-tolerant species such as Corylus americana (American hazelnut), Ceanothus americanus (New Jersey tea), and Amorpha canescens (lead-plant) (NatureServe 2004, Bader 2001, Cottam 1949, Veatch 1927). Shrubs such as Cornus foemina (gray dogwood), Prunus americana (wild plum), and Rhus glabra (smooth sumac) occasionally form thickets in fire-protected microsites (NatureServe2004, Bader 2001, Kline 1997).

The predominantly graminoid ground layer is composed of species associated with both prairie and forest communities. For a given oak savanna, the proportion of forbs to graminoids was likely a function of light availability and soil texture with graminoids increasing with sand and solar irradiance and forb coverage increasing with silt content and shade (Leach and Givnish 1999). Grasses, which provided the primary source of fine fuel for annual fires, reached heights of over a meter in areas of high light intensity (Anderson 1991a). Common grass species included Andropogon gerardii (big bluestem), Schizachyrium scoparium (little bluestem), and Sorghastrum nutans (Indian grass). Prevalent forbs included Amphicarpea bracteata (hog peanut), Anemone virginiana (thimbleweed), Asclepias purpurascens (purple milkweed), Asclepias tuberosa (butterfly-weed), Aster laevis (smooth aster), Coreopsis palmata (prairie coreopsis), Desmodium canadense (showy tick-trefoil), Eupatorium sessilifolium (upland boneset), Euphoribia corollata (flowering spurge), Galium boreale (northern bedstraw), Gentiana flavida (white gentian), Lathyrus venosus (veiny pea), Lespedeza capitata (bush-clover), Monarda fistulosa (wild-bergamot), Pycnanthemum virginianum (mountain mint), Rudbeckia hirta (black-eyed Susan), Silene stellata (starry campion), Solidago juncea (early goldenrod), Taenidia integrima (yellow pimpernel), Triosteum perfoliatum (horse-gentian, feverwort), Veronicastrum virginicum (Culver's root) and Zizia aurea (golden alexanders). (List compiled from NatureServe 2004, Bader 2001, Pruka 1995, Leach and Ross 1995, Packard 1988, Chapman 1984, Bray 1960Curtis 1959).

Disturbance Description

Cottam (1949) and Curtis (1959) suggested that oak savannas originated when prairie fires spread into surrounding closed oak forest with enough intensity to create open canopy conditions (also see Anderson and Bowles 1999, Anderson and Brown 1986). Other researchers have proposed that savannas also originated following invasion of prairie by oaks during prolonged lulls in annual fire regimes (Anderson and Bowles 1999, Grimm 1984). Repeated low-intensity fires working in concert with drought and

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windthrow then maintained these savannas (Faber-Langendoen and Tester 1993, Curtis 1959, Stout 1946). 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. Fires prevented canopy closure and the dominance of woody vegetation (Leitner et al. 1991). 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 prairie and savanna ecosystems (Anderson and Bowles 1999, Bowles and McBride 1998, Dorney and Dorney 1989, Chapman 1984, Grimm 1984, Day 1953). Where large-scale herbivores (i.e., elk and bison) were abundant, grazing may have helped inhibit the succession of oak savanna to woodland (Ritchie et al. 1998, McClain et al. 1993).

The character of oak savannas can differ dramatically, primarily as the result of varying fire intensity and frequency, which are influenced by climatic conditions, soil texture, topography, size of physiographic and vegetative units, and landscape context (i.e., proximity to water bodies and fire-resistant and fire-conducive plant communities) (Anderson and Bowles 1999, Anderson and Bowles 1999, Anderson and Bowles 1999, Chapman et al. 1995). Historically, fire regimes were also influenced by the number and distribution of indigenous peoples (Chapman 1984). Infrequent, high-intensity fires may kill mature oaks and produce savannas covered by abundant scrubby oak sprouts. Park-like openings with widely spaced trees and an open graminoid/forb understory are maintained by frequent, low-intensity fires, which occur often enough to restrict maturation of oak seedlings and encroachment by other woody species (Peterson and Reich 2001, Chapman et al. 1995, Faber-Langendoen and Davis 1995).

Adjacency or Identification Concerns

The northern oak savanna type includes several matrix communities such as mesic and dry-mesic oak openings, dry oak barrens, mixed oak and oak-hickory woodlands, and a variety of small and large patch prairie types.

This type intergrades and can be confused with more open expressions of North-Central Interior Dry-Mesic Oak Forest and Woodland (1310) and North-Central Interior Dry Oak Forest and Woodland (1311). It can be distinguished from these systems in some cases by a higher percentage of sand (though not to the excessive levels of the North-Central Oak Barrens) in Sections 222K and 222R. This type can also intergrade with North-Central Oak Barrens (1395) as soils become increasingly sandy. In 222L it is also associated with moderate levels of silt. In 222K and 222L
it is associated with the SSURGO taxonomic particle size of “fine-silty” and fine-silty over clayey.

Today, northern oak savanna in the upper Midwest is limited to small, degraded remnants. Circa 1800, oak savanna communities covered some 11-13 million ha (27-32 million ac) of the Midwest. Presently oak savanna remnants occur on just 0.02% of their circa 1800 extent (Nuzzo 1986). Following European settlement of prairies, settlement and conversion to agriculture of oak savanna rapidly followed (Kenoyer 1930). Many towns, college campuses, parks, and cemeteries of the Midwest were established on former oak savanna (Packard 1988, Bronny 1989, Chapman 1984).

Alteration of historic fire regimes has shifted most oak savannas into woodlands and forest (Faber-Langendoen 1993, Curtis 1959, Cottam 1949).The decrease in Native American populations across the Midwest in the 1700-1800s likely resulted in a decrease in fire frequency. 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 (Abrams 1992). The reduction of fire in the landscape resulted in the succession of open oak savanna to closed-canopy forests with little advanced regeneration of oaks and a vanishing graminoid component (Chapman et al. 1995). With the absence of

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fire, oak savannas converted to closed canopy forest within decades (estimates range from 25-40yrs) (Stout 1946, Curtis 1959) with more mesic savannas, such as bur oak plains, deteriorating more rapidly (Packard 1993, Abrams 1992). The rapid conversion to oak forest occurred because of the prevalence in the understory of oak grubs, which are repeatedly fire-suppressed oaks with huge root masses that allowed them to achieve canopy ascension following release from annual fires (Bowles and McBride 1998, Kline 1997, Chapman 1984, Cottam 1949). Frequently these oak grubs were Quercus velutina (black oaks), which became canopy codominants with the advent of fire suppression.

Oak savanna remnants are often depauperate in floristic diversity as the result of fire suppression and subsequent woody encroachment, livestock grazing, and the invasion of exotic species. Sustained grazing introduced soil disturbance, prevented oak establishment, and caused decreases in native forbs and grasses with increases in weeds (native and exotic) (Jones 2000, McPherson 1997, Bray 1960). Groundlayer vegetation of savanna remnants has been inhibited by low levels of light filtering through the dense overstories and impenetrable understories (often dominated by exotic shrubs) and by the thick litter layers that have accumulated from over a century of fire suppression (Bowles and McBride 1998).

Native Uncharacteristic Conditions

Scale Description

The expected fire regimes for this type are I (frequent ground fires) and III (mixed severity). The ground fire was the more commonly occurring fire disturbance, but when dry conditions combined with dense stand conditions, a mixed-severity fire could result, with the fire crowning into the canopy where fuel ladders were present. The scale of these fires is thought to occur on tens of thousands of acres.

Issues/Problems

Changed probability of mixed fire in E from 500yrs to 40yrs because of the way surface fire was maintaining system in class E in LANDSUM (about 40-50% of RC) as opposed to disturbance resetting to a more open state (MHW at MiFSL 11-13-07). This type covers a broad geographic range and encompasses a variety of savanna, barrens, woodlands and prairie types that may have experienced different surface fire return intervals ranging from one to five years. Historical fire size is unknown but historical accounts indicate that vast acreages burned within a single fire event.

Comments

This model for the Great Lakes was adapted from the Rapid Assessment model R6NOKS Northern Oak Savanna created by James Merzenich jmerzenich@fs.fed.us, David Cleland dcleland@fs.fed.us, Donald Dickman dickman1@msu.edu, Micahel Kost, Patrick Fowler and Joshua Cohen. For MZs 41, 50 and 51, a large portion of this text was copied directly from Josh Cohen's (Michigan Natural Features Inventory) abstract for oak openings (Cohen 2004a).

Vegetation Classes

Class A **6 %**

Early Development 1 Open

Upper Layer Lifeform

- ☑ Herbaceous
- ☐ Shrub
- ☐ Tree

Fuel Model 3

Indicator Species* and Canopy Position

ANGE	Upper
SCHIZ4	Upper
QUMA2	Upper
	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	100 %
Height	Herb 0m	Herb >1.1m
Tree Size Class	Seedling <4.5ft	

☐ Upper layer lifeform differs from dominant lifeform.

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Description

Prairie grasses and forbs dominate open grassland with scattered oak grubs and clumps of shrubs.

This class ranges from 0-19yrs. A replacement fire (est. at a five year probability) would maintain the system in this class while alternate succession (20yrs without fire-modeled with a probability of 0.05 instead of TSD due to modeling issues) would allow the system to move to class B. Native grazing (est. at an infrequent - 500yr - probability) would also maintain the system in class A.

Class B **16 %**

Mid Development 1 Open

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 3

Indicator Species* and Canopy Position

QUAL	Upper
QUMA2	Upper
ANGE	Lower
CORYL	Middle

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	20 %
Height	Tree 5.1m	Tree 25m
Tree Size Class	Medium 9-21"DBH	

☑ Upper layer lifeform differs from dominant lifeform.

Although trees and shrubs are the upper layer lifeform this class contains a understory of prairie grasses and forbs. Max. tree cover is 10% but herbaceous cover can range up to 100%.

Description

Scattered young oak trees and clumps of shrubs occur within a matrix of prairie grasses and forbs.

This class ranges from 20-50yrs. A wind/weather/stress event (such as a tornado or severe drought) (est. at a 1000yr probability), mixed fire (est. at a 100yr probability), or a replacement fire (est. at 200yr probability) would send the system back to class A. A surface fire (est. at a five year probability) or infrequent native grazing (est. at a 1000yr probability) would maintain the system in class B. Alternate succession (without fire for 30yrs) would allow the system to succeed to class D and alternate succession (50yrs without fire…modeled using probabilities instead of TSD to meet LANDFIRE mapping rules) would allow the system to succeed to class E.

Class C **65 %**

Late Development 1 Open

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 3

Indicator Species* and Canopy Position

QUAL	Upper
QUMA2	Upper
ANGE	Lower
CORYL	Low-Mid

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	21 %	60 %
Height	Tree 5.1m	Tree 25m
Tree Size Class	Large 21-33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

This is a system of widely-scattered, large-diameter oaks and shrub clumps within a matrix of prairie grasses and forbs (10-60% canopy closure).

This class is 51yrs+. A mixed fire (est. at a 200yr probability) would send the system back to class B. A replacement fire (est. at 1000yr probability) would send the system back to class A. A surface fire (est. at a five year probability), infrequent native grazing (est. at a 1000yr probability), or an infrequent

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wind/weather/stress event (such as a tornado or severe drought) (est. at a 1000yr probability) would maintain the system in class C. Alternate succession (without fire for 25yrs) would allow the system to succeed to class D.

Class D 12 %

Late Development 2 Open

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 8

Indicator Species* and Canopy Position

QUAL	Upper
QUMA2	Upper
QUVE	Upper
	Low-Mid

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	61 %	80 %
Height	Tree 5.1m	Tree 25m
Tree Size Class	Very Large >33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Open canopy (60-80% canopy) oak-dominated woodland with high stem density. These oak groves occupy areas of the landscape that frequently escape fire due to topographic position.

This class is 51yrs+. A wind/weather/stress event (such as a tornado or severe drought) or a replacement fire (both est. at 1000yrs) would send the system back to class A. A mixed fire (est. at 500yrs) would send the system back to class C. Surface fire (est. at five years) and infrequent native grazing (est. at 1000yrs) would maintain the system in class D while alternate succession (30yrs without fire) would allow the system to succeed to class E.

Class E 1 %

Late Development 3 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 8

Indicator Species* and Canopy Position

QUAL	Upper
QUMA2	Upper
CAOV2	Upper
PRSE2	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	81 %	100 %
Height	Tree 5.1m	Tree 25m
Tree Size Class	Large 21-33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

This is a closed-canopy (81-100%) oak-dominated forest with scattered hickories. These oak groves occupy areas of the landscape that frequently escape fire due to topographic position.

This class is 51yrs+. A wind/weather/stress event (such as a tornado or severe drought) or a replacement fire (both est. at 1000yrs) would send the system back to class A. A mixed fire (changed to 40yrs - original model est. at 500yrs but piled up too much in LANDSUM this way in E) would send the system back to class C. Surface fire (est. at 10yrs) and infrequent native grazing (est. at 1000 yrs) would maintain the system in class E.

Disturbances

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100-year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement seve

Fire Regime Group:** I

Historical Fire Size (acres)

Avg 100000
Min 50
Max 500000

Sources of Fire Regime Data

- [ ] Literature
- [ ] Local Data
- [x] Expert Estimate

Fire Intervals	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	66.23			0.0151	8
Mixed	208.3			0.0048	2
Surface	5.615			0.1781	90
All Fires	5			0.198	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fir combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inver of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- [ ] Insects/Disease
- [x] Wind/Weather/Stress
- [x] Native Grazing
- [ ] Competition
- [ ] Other (optional 1)
- [ ] Other (optional 2)

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LANDFIRE Biophysical Setting Model

Biophysical Setting 5013950 North-Central Oak Barrens

☐ *This BPS is lumped with:*
☐ *This BPS is split into multiple models:*

General Information

Contributors (also see the Comments field **Date** 3/7/2007

Modeler 1	Michael Kost	kostma@michigan.org	**Reviewer**	Robert Dana	Robert.Dana@dnr.state.mn.us
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Vegetation Type

Upland Savannah/Shrub Steppe

Map Zone

50

Model Zone

☐ Alaska ☐ N-Cent.Rockies
☐ California ☐ Pacific Northwest
☐ Great Basin ☐ South Central
☑ Great Lakes ☐ Southeast
☐ Northeast ☐ S. Appalachians
☐ Northern Plains ☐ Southwest

Dominant Species*

QUAL	CORYL
QUEL	SCHIZ4
QUVE	GABA
ANGE	CAPE6

General Model Sources

☑ Literature
☑ Local Data
☑ Expert Estimate

Geographic Range

Northern-central oak barrens occurs in a complex, shifting mosaic with open prairie, oak savanna and dry oak woodlands in the upper Midwest. This type occurs in southern lower MI, northwestern OH, northern IN, northeastern IL, southern WI and southeastern to northwestern MN. The system is found in sections: 222J: b, h, g and c.

Biophysical Site Description

North-central oak barrens occur on well-drained, nearly level to slightly undulating sandy glacial outwash, and less often on sandy moraines or ice contact features. Oak barrens typically occur in the driest landscape positions, such as ridge tops, steep slopes, south and west facing slopes and flat sand plains. This xeric, fire-prone community is characterized by soils that are infertile, coarse-textured, well-drained sand or loamy sand with medium to slightly acid pH and low water retaining capacity. Soils contain low organic matter and lack the fine-textured illuvial horizon associated with soils of the oak openings (oak savannas) and are thus droughtier. Oak barrens typically occur in bands surrounding prairie (Chapman et al. 1995, Michigan Natural Features Inventory 2003). In general, oak barrens are most prevalent on the western side of major firebreaks such as rivers (Leitner et al. 1991, Grimm 1984, Curtis 1959). In the 1800s, the oak savanna communities (e.g., oak barrens, oak openings, oak savannas) covered some 11 to 13 million ha (27 to 32 million ac) of the Midwest (Nuzzo 1986).

Vegetation Description

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 woods of widely spaced mature oak with virtually no shrub or sub-canopy layer above the open forb and graminoid understory (Chapman et al. 1995, Bowles and

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McBride 1998, Michigan Natural Features Inventory 2003. The physiognomic variations, which occur along a continuum, are the function of the complex interplay between fire frequency and intensity (Chapman et al. 1995). Typically, oak barrens grade into prairie on one edge and dry forest on the other. As noted by Bray (1958) and Curtis (1959), the flora of this community is 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.

The canopy layer generally varies from 5-60% cover (Chapman et al. 1995) and is dominated or co-dominated by Quercus velutina (black oak) and Quercus alba (white oak). These species of oak are also prevalent in the sub-canopy in shrubby clumps, especially where fire intensity is high. In addition, Acer rubra (red maple), Prunus serotina (black cherry), Populus grandidentata (bigtooth aspen), Populus tremuloides (trembling aspen) and Quercus ellipsoidalis (northern pin oak) are often found in the overstory and sub-canopy of this community. Northern pin oak is especially common on excessively well-drained sites. Prevalent species of the subcanopy layer include Cornus spp. (dogwood species), Corylus americana (American hazelnut), Prunus spp. (cherry species), and in MI, Sassafras albidum (sassafras).

Characteristic shrubs include: Amelanchier spp. (serviceberry), Arctostaphylos uva-ursi (bearberry), Ceanothus americanus (New Jersey tea), Comptonia peregrina (sweetfern), Corylus americana, Cornus spp., Corylus cornuta (beaked hazelnut), Cratageus spp. (hawthorn species), Gaultheria procumbens (wintergreen), Gaylussacia baccata (huckleberry), Prunus americana (wild plum), Prunus virginiana (choke cherry), Prunus pumila (sand cherry), Rosa carolina (pasture rose), Rubus flagellaris (northern dewberry), Salix humilis (prairie or upland willow), and Vaccinium angustifolium (low sweet blueberry) and in Michigan, Rhus copalina (shining sumac), and Ptlea trifoliate (hop tree) and Quercus prinoides (dwarf chestnut or dwarf chinkapin oak).

The ground layer is dominated by graminoids and forbs. Common species include Scizhachyrium scoparium (little bluestem), Andropogon gerardii (big bluestem), and Carex pensylvanica (Pennsylvania sedge), with Pennsylvania sedge often replacing the bluestems in shaded areas and fire-suppressed communities. Other prevalent herbs of the oak barrens include: Aster oolentangiensis (sky-blue aster), Aureolaria spp. (false foxglove), Coreopsis lanceolata (tickseed), Cyperus filiculmis (nut grass), Danthonia spicata (poverty oats), Deschampsia flexuosa (hair grass), Euphorbia corollata (flowering spurge), Helianthus divaricatus (tall sunflower), Hypericum perforatum (St. John's-wort), Koeleria macrantha (June grass), Krigia biflora (dwarf dandelion), Lathyrus ochroleucus (white pea), Lespedeza hirta (hairy lespedeza), Liatris aspera (blazing star), Liatris cylindrica (dwarf blazing star), Lupinus perennis (wild lupine), Monarda fistulosa (wild bergamot), Panicum implicatum (grass panicum), Pedicularis canadensis (wood betony), Stipa avenacea (needle grass), Stipa spartea (needle grass), Tephrosia virginiana (goats-rue) and Viola pedata (birdfoot violet).

Disturbance Description

Cottam (1949) and Curtis (1959) suggested that oak savannas originated when prairie fires spread into surrounding closed oak forest with enough intensity to create open canopy conditions (also see Anderson and Brown 1986, Anderson and Bowles 1999). Other researchers have proposed that savannas also originated following invasion of prairie by oaks during prolonged lulls in annual fire regimes (Anderson and Bowles 1999, Grimm 1984). Repeated low-intensity fires working in concert with drought and windthrow then maintained these savannas (Faber-Langendoen and Tester 1993, Curtis 1959, Stout 1946). 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. Fires prevented canopy closure and the dominance of woody vegetation (Leitner et al. 1991). Presently, the

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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 prairie and savanna ecosystems (Anderson and Bowles 1999, Bowles and McBride 1998, Dorney and Dorney 1989, Chapman 1984, Grimm 1984, Day 1953). Where large-scale herbivores (i.e., elk and bison) were abundant, grazing may have helped inhibit the succession of oak savanna to woodland (Ritchie et al. 1998, McClain et al. 1993).

The character of oak barrens can differ dramatically, primarily as the result of varying fire intensity and frequency, which are influenced by climatic conditions, soil texture, topography, size of physiographic and vegetative units, and landscape context (i.e., proximity to water bodies and fire-resistant and fire-conducive plant communities) (Anderson and Bowles 1999, Chapman et al. 1995, Bowles et al. 1994, Grimm 1984). Historically, fire regimes were also influenced by the number and distribution of indigenous peoples (Chapman 1984). Infrequent, high-intensity fires may kill mature oaks and produce savannas and barrens covered by abundant scrubby oak sprouts. Park-like openings with widely spaced trees and an open graminoid/forb understory are maintained by frequent, low-intensity fires, which occur often enough to restrict maturation of oak seedlings and encroachment by other woody species (Peterson and Reich 2001, Chapman et al. 1995, Faber-Langendoen and Davis 1995).

Oak wilt occurred on barrens likely resulting in mortality of larger oak groups especially when they occurred in high densities.

Adjacency or Identification Concerns

The northern oak savanna type includes several matrix communities such as mesic and dry-mesic oak openings, dry oak barrens, mixed oak and oak-hickory woodlands, and a variety of small and large patch prairie types.

This system intergrades with North-Central Interior Oak Savanna (13940) on somewhat sandy sites and North-Central Interior Dry Oak Forest and Woodland (13110) at relatively sharp transitions between areas of higher and lower sand content. This system can be distinguished by high sand content. This system intergrades with Laurentian Pine-Oak Barrens (1407) along its northern extent. This system is found in Province 222 whereas Laurentian Pine-Oak Barrens is found north of the tension zone in Province 212.

In the absence of fire and with the prevalence of anthropogenic disturbance such as logging, off-road vehicle recreation and livestock grazing, the following exotic species may be dominant components of the herbaceous layer of oak barrens: Agropyron repens (quack grass), Agrostis stolonifera (creeping bent), Asparagus officinalis (wild asparagus), Centaurea maculosa (spotted knapweed), Hieracium spp. (hawkweeds), Poa compressa (Canada bluegrass), Poa pratensis (Kentucky bluegrass), Rumex acetosella (sheep sorrel) and Tragopogon dubius (goat's beard).

Native Uncharacteristic Conditions

Scale Description

The expected fire regimes for this type are I (frequent ground fires) and III (mixed severity). The ground fire was the more commonly occurring fire disturbance, but when dry conditions combined with dense stand conditions, a mixed-severity fire could result, with the fire crowning into the canopy where fuel ladders were present. The scale of these fires is thought to occur on tens of thousands of acres.

Issues/Problems

Changed mixed fire probability in classes D and E to send more to C based on LANDSUM results and

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also increased mixed fire from C to B (MHW - MiFSL 11/13/07). This type covers a broad geographic range and encompasses a variety of prairie, barrens, and woodlands types that may have experienced different surface fire return intervals ranging from one to five years. Historical fire size is unknown but historical accounts indicate that vast acreages burned within a single fire event.

Comments

This model for Great Lakes was adapted from the Rapid Assessment model R6NOKS Northern Oak Savanna created by James Merzenich jmerzenich@fs.fed.us, David Cleland dcleland@fs.fed.us, Donald Dickman dickman1@msu.edu, Michael Kost, Patrick Fowler, and Joshua Cohen. Other modelers for MZs 41, 50 and 51 included Josh Cohen and Eric Epstein. For MZs 41, 50 and 51 a large portion of this text was copied directly from Josh Cohen's (Michigan Natural Features Inventory) abstract on oak barren's (Cohen 2001).

Vegetation Classes

Class A 8 %

Early Development 1 All Structure

Upper Layer Lifeform

- [x] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model 3

Indicator Species* and Canopy Position

ANGE	Lower
SCHIZ4	Lower
GABA	Low-Mid
QUVE	Upper

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	100 %
Height	Herb 0m	Herb >1.1m
Tree Size Class	Seedling <4.5ft	

- [ ] Upper layer lifeform differs from dominant lifeform.

Description

Open prairie with grasses and forbs dominating open grasslands with scattered oak grubs and clumps of shrubs.

This class ranges from 0-19yrs. A replacement fire (est. at a five year probability) would maintain the system in this class while alternate succession (20yrs without fire, modeled using a probability instead of TSD) would allow the system to move to class B. Native grazing (est. at an infrequent - 500yr - probability) and an infrequent wind/weather/stress event (such as a tornado or severe drought) (est. at a 500yr probability) would maintain the system in class A. Edaphic conditions (such excessively well-drained, droughty soils), modeled using wind/weather/stress at a 30yr probability, would also maintain the system in class A.

Class B 26 %

Mid Development 1 Open

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model 2

Indicator Species* and Canopy Position

QUVE	Upper
GABA	Low-Mid
ANGE	Lower
SCHIZ4	Lower

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	20 %
Height	Tree 5.1m	Tree 25m
Tree Size Class	Medium 9-21"DBH	

- [ ] Upper layer lifeform differs from dominant lifeform.

Description

Although trees and shrubs are the upper layer lifeform this class contains a understory of prairie grasses and forbs. Max. tree cover is 10% but herbaceous cover can range up to 100%.

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Early successional barrens/brush prairie (1-10% tree canopy) with scattered young oak trees and clumps of shrubs occur within a matrix of prairie grasses and forbs.

This class ranges from 20-50yrs. A wind/weather/stress event (such as a tornado or severe drought) (est. at a 500yr probability), mixed fire (est. at a 100yr probability), or a replacement fire (est. at 200yr probability) would send the system back to class A. A surface fire (est. at a five year probability) or infrequent native grazing (est. at a 1000yr probability) would maintain the system in class B. Edaphic conditions (such excessively well-drained, droughty soils), modeled using wind/weather/stress at a 30yr probability, would also maintain the system this class. Alternate succession (without fire for 30yrs) would allow the system to succeed to class D and alternate succession (without fire for 50yrs) would allow the system to succeed to class E.

Class C **61 %**

Late Development 1 Open

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 2

Indicator Species* and Canopy Position

QUVE	Upper
QUAL	Upper
ANGE	Low-Mid
SCHIZ4	Lower

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	21 %	60 %
Height	Tree 5.1m	Tree 25m
Tree Size Class	Large 21-33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

The canopy layer generally varies from 5-60% cover (Chapman et al. 1989)

Description

Oak barrens: This is a system of widely-scattered, large-diameter oaks and shrub clumps within a matrix of prairie grasses and forbs (11-60% canopy closure).

This class is 51 yrs+. A mixed fire (est. at a 200yr probability) would send the system back to class B. A replacement fire (333yr probability -originally est. at 500yr probability) would send the system back to class A. A surface fire (est. at a five year probability), infrequent native grazing (est. at a 1000yr probability), or an infrequent wind/weather/stress event (such as a tornado or severe drought) (est. at a 500yr probability) would maintain the system in class C. Edaphic conditions (such excessively well-drained, droughty soils), modeled using wind/weather/stress at a 30yr probability, would also maintain the system this class. Alternate succession (without fire for 25yrs) would allow the system to succeed to class D.

Class D **3 %**

Late Development 2 Open

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 8

Indicator Species* and Canopy Position

QUAL	Upper
QUVE	Upper
QUEL	Upper
COAM3	Middle

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	61 %	80 %
Height	Tree 5.1m	Tree 25m
Tree Size Class	Very Large >33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Oak woodland (60-80% canopy) oak-dominated woodland with high stem density. These oak groves occupy areas of the landscape that frequently escape fire due to topographic position.

Disturbances would include tree pathogens such as oak wilt or insect. This class is 51yrs+. A

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wind/weather/stress event (such as a tornado or severe drought) (est. at 500yrs) or a replacement fire (est. at 1000yrs) would send the system back to class A. A mixed fire(59yrs - originally est. at 500yrs) or insect outbreak (est. at 200yrs) would send the system back to class C. Surface fire (est. at five years), infrequent native grazing (est. at 1000yrs), edaphic condition (modeled as wind/weather/stress event at 30yrs) would maintain the system in class D while alternate succession (30yrs without fire) would allow the system to succeed to class E.

Class E 2 %

Late Development 3 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 8

Indicator Species* and Canopy Position

QUAL	Upper
QUVE	Upper
QUEL	Upper
COAM3	Middle

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	81 %	100 %
Height	Tree 5.1m	Tree 25m
Tree Size Class	Large 21-33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

This is a closed-canopy (81-100%) oak-dominated forest. These oak groves occupy areas of the landscape that frequently escape fire due to topographic position.

This class is 51yrs+. A wind/weather/stress event (such as a tornado or severe drought) (est. at 500yrs) or a replacement fire (est. at 1000 yrs) would send the system back to class A. A mixed fire (40yrs - originally est. at 500yrs) would send the system back to class C. Tree pathogens such as oak wilt or an insect outbreak (est. at 200yrs) would send the system to class D. Surface fire (est. at 10yrs), infrequent native grazing (est. at 1000yrs), and edaphic conditions (modeled as wind/weather/stress at 30yrs) would maintain the system in class E.

Disturbances

Fire Regime Group:** I

Historical Fire Size (acres)

Avg 100000
Min 50
Max 500000

Sources of Fire Regime Data

- ☐ Literature
- ☐ Local Data
- ☑ Expert Estimate

Fire Intervals

	Avg FI	*Min FI*	*Max FI*	*Probability*	*Percent of All Fires*
Replacement	72.99			0.0137	7
Mixed	285.7			0.0035	2
Surface	5.456			0.1833	91
All Fires	5			0.2005	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fir combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inver of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- ☑ Insects/Disease
- ☑ Wind/Weather/Stress
- ☑ Native Grazing
- ☐ Competition
- ☐ Other (optional 1)
- ☐ Other (optional 2)

References

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LANDFIRE Biophysical Setting Model

Biophysical Setting 5014071 Laurentian Pine-Oak Barrens

☐ *This BPS is lumped with:*

☑ *This BPS is split into multiple models: This BpS was split into two - 1407-1 (Laurentian Pine-Oak Barrens) and 1407-2 (Jack-Pine Barrens)*

General Information

Contributors (also see the Comments field **Date**

Modeler 1	Doug Cox	mdeecology@frontiernet.net	**Reviewer**	Dave Cleland	dcleland@fs.fed.us
Modeler 2	Becky Schillo	schillor@michigan.gov	**Reviewer**		
Modeler 3			**Reviewer**		

Vegetation Type

Barren

Map Zone

50

Model Zone

☐ Alaska ☐ N-Cent.Rockies
☐ California ☐ Pacific Northwest
☐ Great Basin ☐ South Central
☑ Great Lakes ☐ Southeast
☐ Northeast ☐ S. Appalachians
☐ Northern Plains ☐ Southwest

Dominant Species*

QUAL QUVE
QUEL PIST
QURU PIBA2
QUPA2 PIRE

General Model Sources

☑ Literature
☐ Local Data
☑ Expert Estimate

Geographic Range

Laurentian pine-oak barrens were located on sandy outwash plains located along the climatic tension zone in MI and WI. In MI the system occurs along the Sandusky lakeplain, the Newaygo Outwash Plain, and in several counties of the Upper Peninsula, including Menominee, Dickinson, Delta, and Chippewa counties (Comer et al. 1995). In MI, presently the distribution of this community is concentrated in the Newaygo Outwash Plain with additional remnants in the sandy outwash plains of Menominee and Dickinson counties and the sandy lakeplain of Huron County (Cohen 2000). In MI the system occurred in subsections 212 Ha, Hb, Hg, Ka; 222 Ja, Jb; 212 Tb, Td and 212 Rc.

Laurentain pine-oak barrens also occurred in WI between the southern oak barrens/savanna and northern jack pine barrens (Cochrane and Iltis 2000, Curtis 1959). In WI, this system occurred in subsections 212 Ta, 222 Kb, 222 Ra and Rb, 212 Qa, Qb, Qc, and Qd.

Biophysical Site Description

The Laurentian pine-oak barrens system is endemic to very dry, nutrient-impoverished landscape ecosystems. Pine-oak 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. Soils of this xeric, fire-prone community are generally coarse-textured, well-drained sand or loamy sand of medium to slightly acid pH and low water retaining capacity. Soils typically lack the fine-textured illuvial horizon associated with soils of the oak openings and are thus droughtier. Oak-pine and oak barrens typically occur in bands surrounding prairie (Michigan Natural Features Inventory 1990). They are generally found in transitional areas along the tension zone. (Cohen 2000).

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Vegetation Description

The oak-pine barrens community is a heterogeneous savanna vegetation type. Structurally oak-pine barrens range from dense thickets of brush and understory scrub oak and pine amongst a matrix of grassland to park-like open woods of widely spaced mature oak and pines with virtually no shrub or sub-canopy layer above the open forb and graminoid understory (Chapman et al. 1995, Lohrentz and Mattei 1995, Michigan Natural Features Inventory 1990). The physiognomic variations, which occur along a continuum, are the function of the frequency and intensity of fire (Lohrentz and Mattei 1995). Typically, oak-pine barrens grade into prairie on one front and dry forest on the other. As noted by Curtis (1959), the flora of this community is a mixture of prairie and forest species.

The canopy layer generally varies from 5-60 percent cover (Chapman et al. 1989) and is dominated or co-dominated by the following trees: Quercus alba (white oak), Quercus velutina (black oak), Quercus ellipsoidalis (northern pin oak), Pinus strobus (white pine), Pinus resinosa (red pine) and Pinus banksiana (jack pine). The above species of pine and oak are also prevalent in the sub-canopy in shrubby clumps, especially where fire intensity is high. In addition, Acer rubra (red maple), Prunus serotina (black cherry), Populus grandidentata (bigtooth aspen) and Populus tremuloides (trembling aspen) are often found in the overstory and sub-canopy of this community. Along the transition zone and to the south, the most common overstory dominants are white oak, black oak, and white pine. North of the transition zone, northern pin oak replaces black oak and red pine and jack pine become more prevalent in the canopy layer. (Michigan Natural Features Inventory 1990).

Characteristic shrubs include: Amelanchier spp. (serviceberry), Arctostaphylos uva-ursi (bearberry or kinnikinick), Ceanothus americanus (New Jersey tea), Comptonia peregrina (sweetfern), Corylus americana (American hazelnut), Cornus spp (dogwood species), Corylus cornuta (beaked hazelnut), Cratageus spp (hawthorn species), Gaultheria procumbens (wintergreen), Gaylussacia baccata (huckleberry), Prunus americana (wild plum), Prunus virginiana (choke cherry), Prunus pumila (sand cherry), Quercus prinoides (dwarf chestnut or dwarf chinkapin oak), Rosa carolina (pasture rose), Rubus flagellaris (northern dewberry), Salix humilis (prairie or upland willow) and Vaccinium angustifolium (low sweet blueberry).

The ground layer is dominated by graminoids and forbs. Common species include Scizhachyrium scoparium (little bluestem), Andropogon gerardii (big bluestem), and Carex pensylvanica (Pennsylvania sedge), with Pennsylvania sedge often replacing the bluestems in shaded areas, fire suppressed communities, and north of the transition zone. Other prevalent herbs of the oak-pine barrens include: Aster oolentangiensis (sky-blue aster), Aureolaria spp. (false foxglove), Coreopsis lanceolata (tickseed), Danthonia spicata (poverty oats), Deschampsia flexuosa (hair grass), Euphorbia corollata (flowering spurge), Helianthus divaricatus (Divaricate sunflower), Koeleria macrantha (June grass), Krigia biflora (dwarf dandelion), Lathyrus ochroleucus (white pea), Lespedeza hirta (hairy lespedeza), Liatris cylindrica (dwarf blazing star), Lupinus perennis (wild lupine), Monarda fistulosa (wild bergamot), Pedicularis canadensis (wood betony) and Stipa avenacea (needle grass).

Disturbance Description

Frequent fire and, in some places, frost and drought conditions, maintain open canopy conditions by limiting the development of woody vegetation and thereby allowing the maintenance of a mixture of grasses and sedges.

Curtis (1959) suggested that oak barrens 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

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periodic drought then maintain these barrens. Oak-pine barrens persist when fire disturbance prevents canopy closure and the dominance of woody vegetation. Presently, the prevalent catalyst of such fires is lighting strike but historically, Native Americans played an integral role in the fire regime, accidentally and/or intentionally setting fire to prairie ecosystems (Chapman 1984, in Lohrentz and Mattei 1995).

The character of oak-pine barrens can differ dramatically as the result of varying fire intensity and frequency, which is influenced by climatic conditions, soil texture, and topography. Infrequent, high intensity fires kill mature oaks and produce barrens covered by scrubby oak sprouts and scattered pines, which survived the burn. Park-like barrens with widely spaced trees and an open grass understory are maintained by low intensity, frequent fires, which occur often enough to restrict oak seedlings (Chapman et al. 1995, Lohrentz and Mattei 1995). Frequent fires of low intensity can maintain high levels of grass and forb diversity by deterring the encroachment of woody vegetation and limiting the dominance of the mat-forming sedge Carex pensylvanica, (Pennsylvania sedge) (Corner 1996).

Diseases such as oak wilt also influenced the structure and species composition of pine-oak barrens. Oak wilt would have affected all oak species with white oak being more resistant to wilt than other oak species. Two-lined chestnut borer would affect oak species. Budworms could also pine species in the barrens. These insect breaks would have eliminated groups or clumps of trees.

Intense weather events such as tornados, down-bursts, or severe windthrow would have been infrequent in this system but severe if and when they did occur.

Adjacency or Identification Concerns

Most of the historical oak-pine barrens have been degraded by selective logging, livestock grazing and fire suppression or destroyed by extensive timber harvest followed by slash fires and conversion to tree farms or plantations. Plant species of oak-pine barrens can persist through cycles of canopy closure and removal (Chapman et al., 1989).

Laurentian pine oak barrens may be confused with or mistaken for BpS 1407-2 Jack Pine Barrens, BpS 1395 North-Central Oak Barrens, or 1394 North-Central Interior Oak-Savanna. This system may also be referred to as jack pine barrens, oak barrens, or simply barrens. This system can be distinguished from North-Central Oak Barrens (13950) based on greater dominance of Jack pine, and it becomes the more likely barrens oak type in Province 212.

Currently much of this system may be in a closed state due to fire suppression and may exist as a closed canopy oak or pine forest. Additionally, a large portion of the historic range of this system has been planted to pine plantation.

In the absence of fire and with the prevalence of anthropogenic disturbance such as logging, off-road vehicle recreation, and livestock grazing, the following exotic species may be dominant components of the herbaceous layer of oak-pine barrens: Centaurea maculosa (spotted knapweed), Hieracium spp. (hawkweeds), Poa compressa (Canada bluegrass), Poa pratensis (Kentucky bluegrass) and Rumex acetosella (sheep sorrel).

Native Uncharacteristic Conditions

Scale Description

Historically there was considerable variation in the size and intensity of fires in pine-oak landscapes. As a

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result pine-oak barrens existed as a small to large patch within a matrix of prairies, barrens and pine-oak forests.

Issues/Problems

Need to acquire more detailed information about distribution of pine-oak barrens in Minnesota. Need more research on frequency of historical surface fire. What constitutes pine-oak barrens versus pine-oak forest or dry sand prairie depends on temporal and spatial scales.

Comments

A majority of the text in this description document was copied directly from the Oak-Pine Barrens Natural Community Abstract created by Joshua Cohen (cohenjo@michigan.gov) of the Michgian Natural Features Inventory.

Comments below are from a reviewer. Original modeler did not agree with proposed changes:

SClass B:
So once it gets closed, it loses most of its probability to have fire?? There are fires all around this class in the landscape, and I'd say once it hits this point of canopy closure its probability of stand replacing fire goes through the roof. The majority of fires in this state should be stand replacement, not mixed, given the rates of replacement fire in D.

SClasses C and D:
There needs to be a replacement fire for these, it is possible and needs to be accounted for. It can be relatively slight (~5% of fires in these classes).

SClass E:
Same comment as B, but proportionally a little more mixed fire (~25% of all fires). There needs to be some surface fire in this (~25% of all fires). The remainder should be replacement.

Vegetation Classes

Class A 8 %

Early Development 1 All Structure

Upper Layer Lifeform

- ☑ Herbaceous
- ☐ Shrub
- ☐ Tree

Fuel Model

Indicator Species* and Canopy Position

SCHIZ4	Lower
CAPE6	Lower
ANGE	Lower
	Lower

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	90 %
Height	Herb 0m	Herb >1.1m
Tree Size Class	None	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Grasses and sedges are dominant lifeform but oak sprouts and pine seedlings may be taller than the grasses and sedges at the end of this stage.

In this class sedges and grasses are dominant, with scattered oak grubs, pine regeneration and low shrubs. There would also be oak re-sprouts from top-killed trees. This class would persist on the landscape for 0-10yrs. With time, class A succeeds to class C. A replacement fire (est, at a probability of 200yrs) would take the class back to time zero and maintain the system in class A. Parts of the landscape with a more frequent fire would be maintained as a grassland system and captured in a different model.

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Although it is not possible to model compound disturbances in VDDT, historically subsequent fires occurring within a short time period (i.e. two or more fires within 10-20yrs) could produce scrub oak structure with shrubby, small-stemmed patches of oaks and shrub species interspersed with patches of prairie grasses (Will-Wolf and Stearns in Anderson et al. 1999). This vegetation is also captured in class A of this model.

Class B **1 %**

Mid Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

PIBA2	Low-Mid
QUEL	Low-Mid
QUAL	Low-Mid
PIRE	Low-Mid

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	61 %	100 %
Height	Tree 5.1m	Tree 10m
Tree Size Class	Pole 5-9" DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

This stage is a mid-seral closed stage dominated by dense oak and pine saplings with shade intolerant shrubs coming in under the tree saplings. This class would result from the of absence of fire for a period of 30yrs and would persist for 20yrs. With time - the class will succeed to class E (late closed stage). A mixed severity fire (200yr probability) would open up this mid-closed stage and transition it to class C.

Class C **25 %**

Mid Development 2 Open

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

QUEL	Upper
PIBA2	Upper
PIRE	Upper
SCHIZ4	Lower

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	20 %	60 %
Height	Tree 5.1m	Tree 10m
Tree Size Class	Pole 5-9" DBH	

☑ Upper layer lifeform differs from dominant lifeform.

Grasses and sedges are dominant lifeform although scattered oaks and pines would be the upper layer lifeform. Typically herbaceous species are less than a meter in height. Minimum cover for herbaceous species is approximately 40%, while maximum coverage is 70%.

Description

The vegetation of this class consists of sedges and grasses in the groundlayer with a scattered canopy of oaks and pine trees and low shrubs. Tree species may occur singly or in small clumps. Maple and aspen species may also be present.

Frequent surface fires and mixed-severity fires maintain this class. Frequent surface fires are modeled to have occurred with a five year probability with mixed severity fires at a 100yr probability. This class would persist from time 11-50yrs. With time and fire the class would succeed to class D. Without fire for 30yrs the vegetation would close in and would transition to class B.

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Class D 65 %

Late Development 1 Open

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

PIBA2	Upper
QUEL	Upper
PIRE	Upper
SCHIZ4	Lower

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	21 %	60 %
Height	Tree 10.1m	Tree 50m
Tree Size Class	Very Large >33"DBH	

☑ Upper layer lifeform differs from dominant lifeform.

Description

Grasses and sedges are dominant lifeform although scattered oaks and pines would be the upper layer lifeform. Typically herbaceous species are less than a meter in height. Minimum cover for herbaceous species is approximately 40%, while maximum coverage is 70%.

The vegetation of this class is similar to class C except that this class has more mature trees (over 51yrs in age). Aspen and other pioneer species would senesce between 60-80yrs. This class would be maintained by frequent surface fires with a five year probability and mixed fires with a 60yr probability. A replacement fire with a 100yr probability would send the class back to A.

Class E 1 %

Late Development 2 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

PiBA2	Upper
PIRE	Upper
QUEL	Upper
QUVE	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	61 %	100 %
Height	Tree 10.1m	Tree 50m
Tree Size Class	Very Large >33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

This class is a closed-canopy pine-oak forest that results after prolonged periods of fire suppression or microtopography that protects forest from fires (approximately 50 plusyrs). This class ranges from time 51yrs to a mature persistent closed canopy forest. Class E could move to class D (late open stage) with a several mixed fires that occurred in close succession (100yr probability in VDDT).

Disturbances

Fire Regime Group: I

Historical Fire Size (acres)

Avg
Min
Max

Sources of Fire Regime Data

- ☑ Literature
- ☐ Local Data
- ☑ Expert Estimate

Fire Intervals

	Avg FI	*Min FI*	*Max FI*	*Probability*	*Percent of All Fires*
Replacement	106.4			0.0094	4
Mixed	740.1			0.00135	1
Surface	4.739			0.211	95
All Fires	5			0.22175	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fir combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inver of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

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Additional Disturbances Modeled

☐Insects/Disease ☐Native Grazing ☐Other (optional 1)
☐Wind/Weather/Stress ☐Competition ☐Other (optional 2)

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LANDFIRE Biophysical Setting Model

Biophysical Setting 5014072 Laurentian-Acadian Jack Pine Barrens and Forest

☐ *This BPS is lumped with:*

☑ *This BPS is split into multiple models:* *This model is for the jack pine barrens and forests of central WI and central MN. It can be considered a spilt from the Laurentian Pine-Oak Barrens (BpS 1407) or treated as a new BpS. In this instance it is treated as a spilt.*

General Information

Contributors (also see the Comments field **Date** 3/21/2007

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Vegetation Type

Forest and Woodland

Map Zone

50

Model Zone

☐ Alaska ☐ N-Cent.Rockies
☐ California ☐ Pacific Northwest
☐ Great Basin ☐ South Central
☑ Great Lakes ☐ Southeast
☐ Northeast ☐ S. Appalachians
☐ Northern Plains ☐ Southwest

Dominant Species*

PIBA2	VAAN
CAPE6	COMPT
QUEL	PIRE
GAPR2	ARUV

General Model Sources

☑ Literature
☐ Local Data
☑ Expert Estimate

Geographic Range

System occurs in northern lower MI, northern WI (212Ka), northern MN and eastern Ontario, north of the climatic tension zone (Curtis 1959) and is concentrated in the High Plains subsection in northern lower MI and in central WI subsection 212Q (Vora 1993). Also occurs in several locations in the Upper Peninsula of MI, and in northeastern WI (212Te) and is associated with the upper Mississippi and St. Croix Rivers in MN and WI (Comer 1996). There are scattered cases in WI's Northern Forest (212X).

Biophysical Site Description

The jack pine barrens system is endemic to very dry, nutrient-impoverished landscape ecosystems. These ecosystems occur in landforms deposited by high-energy glacial melt waters, principally outwash plains and glacial lakebeds, underlain by well-sorted, coarse-textured sandy soils with low water retaining capacity. They also occur in bedrock-controlled landforms with shallow soils of limited moisture storage capacity (Cleland et al. 2004). They are generally found in cooler climates north of the tension zone. The topography is flat to gently rolling, typically with long expanses capable of carrying wildfires with few natural fire breaks. In rolling topography, pine barrens are found among depressions that collect cold air, forming frost pockets. The soils of this community are sandy, acidic, droughty and relatively infertile (Comer 1996). They become established in areas with continental climate, in which summers are typically short and warm to cool, and winters are cold (Pregitzer and Saunders 1999).

Vegetation Description

Pinus banksiana (jack pine) typically dominates the scattered overstory canopy. Trees can occur as scattered individuals or in scattered clumps. Closed canopy forest of jack pine were also present with

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absence of fire (Kotar 2002 Region 1). Several other tree species can be found in this community. Historically, there was commonly a scattered supercanopy of Pinus resinosa (red pine). Most of these trees were likely removed during the logging era. Pinus resinosa and Pinus strobus (white pine) were occasionally common sub-dominants in WI pine barrens. Quercus ellipsoidalis (northern pin oak), Prunus serotina (black cherry) and Populus spp. (aspens) are often found as stunted or young trees. Vaccinium angustifolium (low bush blueberry), Comptonia peregrina (sweet-fern), Prunus pumila (sand cherry), Salix humilis (prairie willow) and Corylus spp. (hazelnuts) make up most of the shrub layer when present. Danthonia spicata (poverty grass), Schizachyrium scoparium [Andropogon scoparius] (little bluestem) and Carex pensylvanica are dominant herbaceous species across the range of this community. Other herbs and forbs vary from one location to another, depending on local site conditions. Andropogon gerardii (big bluestem), Deschampsia flexuosa (hair grass), Viola pedata (birdfoot violet), Aster oolentangiensis (prairie heart-leaved aster), Cirsium hillii (Hill's thistle), Koeleria macrantha (June grass), Liatris aspera (rough blazing star), Potentilla arguta (prairie cinquefoil) and Stipa spartea (needle grass) are found on most sites (Comer 1996).

At Crex Meadows in western WI, Vogl (1961) studied pine barrens as described by original land survey records. He estimated that there were 20 trees greater than 15cm (6in) in diameter per hectare. This translates to an average distance between trees of 24m (65ft). The trees in this community had typical open-grown shapes. They had branches most of the way down their trunks with many needles. Many burned jack pine snags were encountered by land surveyors in Michigan. Zimmerman (1956) reported that the tallest tree in his 50 study sites was 16m (52ft). The average tree height was only 8m (26ft). This may be misleading because past logging may have eliminated the largest trees and there has not been enough time to regenerate the tallest pines. Vogl (1961), in his analysis of General Land Office surveys conducted in western WI, found that the average diameter of Pinus banksiana was 25cm (10in) and of P. resinosa was 50cm (20in). This indicates that taller trees may have existed before logging and the subsequent slash-fires that swept through most barrens.

Disturbance Description

Frequent fire and, in some places, frost and drought conditions, maintain open canopy conditions by limiting the development of woody vegetation and allowing the maintenance of a mixture of grasses and sedges. Pine barrens were found in the most fire-prone and driest areas of the landscape, often west of natural fire breaks. Barrens typically occur within long expanses capable of carrying wildfires with few natural fire breaks. In rolling topography, pine barrens are found in depressions that collect cold air, forming frost pockets (Comer 1996).

There are numerous estimates of fire return interval for upland jack pine systems depending on scale and geographic location of study. Whitney (1986) estimated average return time for canopy replacement fire in jack pine forests of northern lower MI to be about 80yrs. Similar return times (50-100yrs) have been estimated by Heinselman (1981) in MN. Whitney (1986) also estimated that surface fires occurred every 25yrs, while Heinselman (1981) suggested that on drier sites light to moderate surface fires may have occurred every 20-40yrs. Simard & Blank (1982) calculated presettlement fire frequency in the Mack Lake area of Oscoda County, MI to have averaged in the range of 13-41yrs. Historical reports document near-annual fires in barrens (Curtis 1959). In a synthesis of the fire literature for historic fire return intervals for the Great Lakes Region Dickman and Cleland(2002) report that the fire return interval for jack pine barrens ranged from 15-60yrs and fires may have even occurred on an annual basis. It is likely that the frequency of fires depended in part to indigenous burning.

Insect infestations in jack pine are also an important disturbance factor, often followed by canopy fire.

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Currently, jack pine budworm infestations can lead to stand-level mortality but it is unclear how the insect behaved in presettlement. GLO data indicate that fire and windthrow were important in some barrens landscapes (Comer et al. 1995, Corner and Albert 1999). This system falls within Fire Regimes I and II.

Adjacency or Identification Concerns

Jack pine barrens often occurred on extensive areas of outwash plain intermixed with dry sand prairie and closed-canopy jack pine systems. The system grades into oak barrens and savannas in the south and into northern pine (oak) forests along to the north. It may be confused with Laurentian Pine-Oak Barrens (BpS 1407).

Many areas that once supported pine barrens and closed jack pine forests have been planted to red pine plantations. Also, current logging practices, clear cutting of jack pine without fire or reforestation practices, these sites have converted to aspen and birch stands.

Other classifications: Michigan Natural Features Inventory (MNFI) natural community classification: pine barrens. The Nature Conservancy National Classification: CODE: (III.A.4a.SW20.00). Alliance: Pinus banksiana-P. resinosa (sparse woodland alliance) Association: Pinus banksiana-P. resinosa/Schizachyrium scoparium-prairie forb (sparse woodland). NatureServe Terrestrial Ecological Classification: Laurentian Pine-Oak Barrens. Kotar habitat type Group 1.

Native Uncharacteristic Conditions

Scale Description

This is matrix system that included prairie/barrens, savanna, and closed canopy forests. The patterning of these patch types was influenced by variation in the size, intensity and frequency of fires. Fire size, frequency and intensity was dependent on natural features, soil types, topography, climatic factors and the concentration of indigenous people.

Issues/Problems

Need to acquire more detailed information about distribution of pine barrens in MN. Need more research on frequency of historical surface fire. This model constitutes all jack pine dominated systems in MZ50. We incorporated dry sand prairie, jack pine barrens and jack pine forest into one model with each vegetation type representing a seral stage in the model. The amount of the landscape in each of these seral stages (dry sand prairie, jack pine barrens and jack pine forest) depended on temporal and spatial scales and was closely linked with fire return intervals. This differs from how the modelers in MZ51 (MI) chose to model jack pine systems. In MZ51 there are separate models for jack pine forests and jack pine barrens.

Comments

Suggested reviewers: USFS - Chequamegon National Forest - Washburn District Forest personnel (Jerry Jaskowiak, Robert Raade, Scott Posner, Ralph Bloomquist); BIA - Midwest Region Tom Remus (218) 327-4793, mail364926@pop.net

This model was adapted from the Rapid Assessment model R6JAPI (Great Lakes Jack Pine Barrens) completed by Joshua Cohen. A majority of the text in the General Information section remains the same from the RA model except that this model was slighty altered for WI (MZ50). This model also diifered in that it combines jack pine barrens and forest into one model with the forest as the late closed seral stage of the model. The Great Lakes Jack Pine Forest was modeled seperately in the Rapid Assessment and in MZ51, as a result we completed a new VDDT model and changed the Vegetation Classes section.

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Comments from the RA model: Eric Epstein, Dave Cleland, Bill Patterson, Greg Nowacki, Andi Koonce, Jim Merzenich, Pat Fowler, Rich Corner, Pat Comer, Dennis Albert. Cleland, Patterson, Nowacki, Koonce, and Merzenich developed an FRCC model for the coarse assessment for jack pine/open land with frequent (high) fire return interval specific to northern MN.

Vegetation Classes

Class A 15 %

Early Development 1 All Structure

Upper Layer Lifeform

- [x] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model 1

Indicator Species* and Canopy Position

CAPE6	Lower
SCSC	Lower
PIBA2	Lower
VAAN	Lower

Structure Data (for upper layer lifeform)

	Min	Max
Cover	41 %	90 %
Height	Herb 0m	Herb 10.0m
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform.

Description

Grasses and sedges are dominant lifeforms. Typically, herbaceous species are less than a meter in height. Minimum cover for herbaceous species is approximately 40% while maximum coverage is 90%.

Sedges and grasses are dominant, with scattered jack pine/pine regeneration and low shrubs. Replacement fire modeled in VDDT every five years. Fires that occurred in this class was modeled as a replacement fires as it would top kill more than 75% of the grass and sedge vegetation. (This is most likely responsible for the higher percentage of replacement fire versus surface fire in the system). This age class ranges from 0-5yrs. This class succeeds to class B.

Class B 25 %

Mid Development 1 Open

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model 4

Indicator Species* and Canopy Position

PIBA2	Low-Mid
PIRE	Low-Mid
QUEL	Low-Mid
CAPE6	Lower

Structure Data (for upper layer lifeform)

	Min	Max
Cover	21 %	70 %
Height	Tree 0m	Tree 5m
Tree Size Class	Sapling >4.5ft; <5"DBH	

- [x] Upper layer lifeform differs from dominant lifeform.

Description

The upper layer lifeform varies depending on the spatial scale. Jack pine and other trees form clumps interspersed within a matrix of grasses and sedges.

Dominated by jack pine regeneration (seedlings or saplings), with scattered red pine and northern pin oak, isolated cases of birch and aspen. A patchwork of clumps of regenerating trees with areas of grass. Replacement fires, modeled at the probability of occurring every 60yrs, would send class B to class A. Surface fire, modeled at the probability of occurring every 50yrs, and mixed fire, modeled at the probability of occurring every 25yrs, would maintain the system in this class.

This class ranges from 6-15yrs. With time this class succeeds to class C. This age class was set to end at 15yrs because jack pine seeds are not usually viable until 15yrs. Therefore, if a replacement fire burned through stands younger then 15yrs the jack pine seed source would not be present and the system would convert to another BpS. Fuel Model 4 was chosen to represent the young closed regen jack pine.

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Class C 51 %

Late Development 1 Open

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 2

Indicator Species* and Canopy Position

CAPE6	Lower
PIBA2	Upper
VAAN	Lower
QUEL	Middle

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	21 %	70 %
Height	Tree 5.1m	Tree 25m
Tree Size Class	Medium 9-21"DBH	

☑ Upper layer lifeform differs from dominant lifeform.

The upper layer lifeform varies on spatial scales in some areas grasses and sedges are dominant lifeform. Typically herbaceous species are less than a meter in height. Minimum cover for herbaceous species is approximately 40%, while maximum coverage is 70%. In other areas the dominant life will be jack pine growing in patches.

Description

Sedges and grasses are dominant, with scattered jack, red, and white pine trees and low shrubs. Frequent surface fires, modeled at the probability of occurring every 10yrs, and mixed-severity, modeled at the probability of occurring every 40yrs, fires maintain this class. A replacement fire, modeled with the probability of occurring every 60yrs, would send the system back to class A. Without fire for 10yrs, modeled as alternate succession, moves to class D.

A jack pine budworm outbreak that could set the system back to class B (modeled as insect/disease on a 500yr basis). A major blowdown followed by a fire (modeled as optional 1 on a 500yr basis) would send the system to class A. Year class 16yrs+.

Class D 9 %

Late Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 9

Indicator Species* and Canopy Position

PIBA2	Upper
QUEL	Mid-Upper
GAPR2	Lower
PIRE	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	71 %	100 %
Height	Tree 5.1m	Tree 25m
Tree Size Class	Medium 9-21"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Closed-canopy jack pine forest that results after prolonged periods (25yrs) of fire suppression or microtopography that protects forest from fires. Surface fires, modeled at the probability of occurring every 60yrs, would maintain the system in this class. Replacement fires, modeled at the probability of occurring every 700-1000yrs, would send the system back to class A. Age class 26yrs+.

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Class E **0 %**

[Not Used] [Not Used]

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☐ Tree

Fuel Model

Description

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	%	%
Height		
Tree Size Class		

☐ Upper layer lifeform differs from dominant lifeform.

Disturbances

Fire Regime Group: I**

Historical Fire Size (acres)

Avg 200
Min 100
Max 10000

Sources of Fire Regime Data

- ☑ Literature
- ☐ Local Data
- ☑ Expert Estimate

Fire Intervals

	Avg FI	*Min FI*	*Max FI*	*Probability*	*Percent of All Fires*
Replacement	25	10	80	0.04	34
Mixed	50	10	80	0.02	17
Surface	17.24	1	20	0.058	49
All Fires	8			0.118	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fir combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inver of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- ☑ Insects/Disease
- ☐ Native Grazing
- ☑ Other (optional 1) Optional 1 (wind followed by fire)
- ☐ Wind/Weather/Stress
- ☐ Competition
- ☐ Other (optional 2)

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LANDFIRE Biophysical Setting Model

Biophysical Setting 5014090 Great Lakes Alvar

☐ *This BPS is lumped with:*
☐ *This BPS is split into multiple models:*

General Information

Contributors (also see the Comments field **Date** 4/3/2007

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Modeler 2	Becky Schillo	schillor@michigan.gov	**Reviewer**		
Modeler 3			**Reviewer**		

Vegetation Type

Barren

Map Zone

50

Model Zone

☐ Alaska ☐ N-Cent.Rockies
☐ California ☐ Pacific Northwest
☐ Great Basin ☐ South Central
☑ Great Lakes ☐ Southeast
☐ Northeast ☐ S. Appalachians
☐ Northern Plains ☐ Southwest

Dominant Species*

THOC2 AGROS2
JUCO6 DECA18
CARI POTR5
DASP2 PIGL

General Model Sources

☑ Literature
☐ Local Data
☐ Expert Estimate

Geographic Range

Great Lakes alvars occur in MI (Lee et al. 1998), NY (Reschke 1990), OH, WI (Judziewicz 2001) and the Canadian province of Ontario (Brownell and Riley 2000). In MI, alvar occurs in the Upper Peninsula near 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 further west and inland along the Escanaba River. In the Lower Peninsula, alvars occur on Thunder Bay Island and along the Lake Huron shoreline near Rogers City, Alpena, and Thompson's Harbor. In MI, alvars are found in subsections 212Hi, 212Rd, 212Re, and 212Rc. In WI, alvars are found on the Door Peninsula, subsection 212Tf.

Biophysical Site Description

Alvar is a biologically distinct geological feature associated with Silurian, Ordovician and Devonian limestone and dolomite bedrock occurring along the Niagara escarpment and cuestra of the Laurentian Great Lakes.

In MI, alvars are commonly found near northern Great Lakes shores where flat bedrock pavement associated with the Niagara Escarpment is exposed (Albert et al. 1997a, 1997b). The bedrock of the Niagara Series is Silurian age limestone and dolostone formed from marine reefs that were common in shallow portions of the Michigan Basin (Ehlers 1973); all sites on the northern shore of Lake Michigan, including the Escanaba River and Garden Peninsula alvars, are of Silurian age. This formation typically dips gently (average one percent slope) toward the south into the Michigan Basin. Ordovician age limestone and dolomite also support these plant communities on northern Drummond Island, while Devonian-age limestone occurs in Presque Isle and Alpena counties in lower MI. Being formed from marine organisms, these rocks are rich in calcium carbonates. Resistance to erosion is variable; limestone and dolostone are readily dissolved by rain water, producing solution cracks or grykes that often connect to the underlying groundwater system. In contrast, argillaceous limestone rich in sand, silt, or clay from

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terrestrial sources is more resistant to solution and typically contains few broad cracks. The proximity of alvars to the Great Lakes results in moderated climate and high precipitation.

Alvar is characterized by shallow soil over bedrock, with soil depth usually <25cm. Soil texture is primarily loamy sand or sandy loam. Soil is saturated, or locally inundated in the spring, but it becomes droughty later in the summer. Thin layers of organic soil may develop in shallow depressions that remain wet for longer periods. The soils and substrate are neutral to slightly alkaline (pH 6.7-8.0).

Vegetation Description

Alvars are dominated primarily by grasses and sedges, with mosses and lichens dominant in the driest areas, and scattered shrubs and occasionally trees in areas where the soil depth is greatest or where cracks or grykes provide additional moisture needed by woody vegetation (Reschke et al. 1999). Several different alvar communities are described on the basis of drainage differences, ranging from "tufted hairgrass wet alvar grassland" on the wettest sites to "juniper alvar shrubland" on the driest sites, which never flood (Reschke et al. 1999). Dominant grasses and sedges include Schizachyrium scoparium (little bluestem), Sporobolus heterolepis (prairie dropseed) and Carex scirpoidea (bulrush sedge). Where soil-water availability is greater, Eleocharis compressa (flattened spike-rush), Andropogon gerardii (big bluestem), Muhlenbergia richardsonis (mat muhly) and Spartina pectinata (cordgrass) are often dominant.

The following species were present in over 50% of five diverse alvar sites from Michigan across Canada to New York. Characteristic grasses included Agrostis hyemale (ticklegrass), Bromus kalmii (Kalm's brome), Danthonia spicata (poverty grass) and Deschampsia caespitosa (tufted hairgrass). Sedges include Carex crawei (Crawe's sedge), C. richardsonii (Richardson's sedge), C. scirpoidea (bulrush sedge) and Eleocharis elliptica (golden-seeded spike-rush). Herbs included Antennaria neglecta (small-leaved pussytoes), Aquilegia canadensis (wild columbine), Arabis hirsute (hairy rock cress), Arenaria stricta (rock sandwort), Campanula rotundifolia (harebell), Castilleja coccinea (Indian paintbrush), Cerastium arvense (field chickweed), Comandra umbellate (bastard-toadflax), Lepidium virginicum (common peppergrass), Monarda fistulosa (wild bergamot), Potentilla arguta (prairie cinquefoil), Ranunculus fascicularis (early buttercup), Calaminta arkansana (low calamint), Senecio pauperculus (balsam ragwort) and Solidago nemoralis (old-field goldenrod). Characteristic shrubs include Juniperus communis (common juniper), Potentilla fruticosa (shrubby cinquefoil), Rhus aromatica (fragrant sumac), Prunus virginiana (choke cherry) and Symphoricarpos albus (snowberry).

Characteristic trees include Thuja occidentalis (northern white-cedar), Picea glauca (white spruce), Pinus strobus (white pine) and Populus tremuloides (trembling aspen). Cryptogram diversity (mosses, lichens, and liverworts) is also high on alvar (Marr 1997), but additional comprehensive surveys are needed.

Disturbance Description

The main disturbance in alvar systems is created by the presence of bedrock at or near the surface which results in seasonal flooding from fall through spring, often followed by summer drought in July and August, when seasonal pools dry up and vegetation is under drought stress (Reschke et al. 1999, Rosen 1995, Stephenson and Herendeen 1986). Surface temperatures can reach 43-53 degrees C (109 to 127 degrees F) (Schaefer and Larson 1997, Gilman 1995). Glacial scour has created small, shallow depressions in the bedrock, which can flood either seasonally or year round, creating herb-, shrub-, or tree-dominated wetlands within the alvar landscape.

Flooding is less prevalent where there are abundant enlarged cracks (grykes) in the rock, which provide improved internal drainage. Grykes form along naturally occurring rock joints as water rich in carbon dioxide forms carbonic acid, which causes high rates of limestone dissolution. The concentration of

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decomposing vegetation and respiring roots in the rock joints also contributes high levels of carbon dioxide in the rock joints, accelerating the rate of limestone dissolution. Sites with many of these cracks that enhance internal drainage are more prone to early desiccation and drought. Many of the widest grykes occur under forest cover, probably because of denser rooting and large accumulations of decomposing vegetation.

Fire, both natural and human-induced, has been documented for Great Lakes alvars in both the United States and Canada (Jones and Reschke 2005, Catling and Brownell 1998), but the fire-regime is believed to be quite variable and fire is not considered important for maintaining biologically diverse alvar (Reschke et al.1999, Schaefer and Larson 1997). Grazing by native ungulates may have also been is important for reducing woody encroachment (Rosen 1992, 1995, Bengtsson et al. 1988, Titlyanova et al. 1988). Due to shallow soil, poor drainage and resultant shallow rooting of plants, windthrown trees occur on or adjacent to the alvar.

Adjacency or Identification Concerns

There are several types of alvar community types - alvar pavement, alvar shrubland, alvar grassland, alvar savanna and alvar woodlands. The model description here focuses on the alvar grassland community although VDDT model attempts to capture several of these community types including alvar pavement, alvar grassland and alvar glade and alvar woodland. The patterning of alvar pavement, grassland, shrubland, savanna, and woodland on the landscape is dependent on amount of soil development over bedrock, drainage conditions, and proximity to seed sources. Therefore although these community types may occur together in a matrix setting - they are not exactly successional classes of each other within the time frame of the model. The distribution and patterning of these community types are controlled much more by abiotic factors than by successional and disturbance factors.

Principle threats to alvar communities are over-grazing, alteration of hydrology with road construction and off-road vehicle use, construction of summer residences within the open grassland and quarry development (Reschke et al. 1999).

Native Uncharacteristic Conditions

Scale Description

Alvars are small to large patch systems that can include a matrix of several of the alvar community types (pavement, grassland, shrubland, glade and woodland).

Issues/Problems

See adjacency/identification concerns section.

Comments

The text of this document (except for the adjaceny/identification issues section) comes from the Michigan Natural Features Inventory Alvar Abstract by Dennis Albert. See Reference section for citation and references cited in the abstract.

Vegetation Classes

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Class A 45 %

Early Development 1 All Structure

Upper Layer Lifeform

- [x] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model

Indicator Species* and Canopy Position

JUCO6	Low-Mid
SCHIZ4	Lower
DASP2	Lower
ELCO2	Lower

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	100 %
Height	Herb 0m	Herb >1.1m
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform.

Description

Alvar pavement and grassland phase: This stage is the essentially a grassland that occurs on thin soils over bedrock. Grasses include (little bluestem) Schizachyrium scoparium, (poverty oat grass) Danthonia spicata, (panic grass) Panicum spp. and (sedges) Carex spp. Seasonally wet these grasslands may also support species such as tufted hairgrass (Deschampsia caespitosa), spikerush (Eleocharis compressa), cordgrass (Spartina pectinata) and rushes (Juncus spp.) (Catling and Brownell 1995). Interspersed within an alvar grasslands may be open areas of exposed bedrock (pavement) where vegetation is restricted to grykes.

Abiotic factors (such as the proximity of bedrock to the soil surface) combined with seasonal flooding and drought limit the encroachment of trees and shrubs into the alvar grassland system, yet as soil development increases (a time scale not modelable for LANDFIRE) trees and shrubs will be able to establish moving this system to an alvar glade (class B). Alternate succession, using a probability of occurring every 500yrs, was used to model the transition from alvar grassland to alvar glade. Seasonal flooding (spring) followed by summer drought was modeled as "optional 1" with a probability of occurring every two years but this may occur on an annual basis. Also replacement fires may burn through alvar grasslands, modeled with a probability of occurring every 300yrs (Jones and Reschke 2005).

Class B 40 %

Mid Development 1 Open

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model

Indicator Species* and Canopy Position

PIGL	Upper
BEPA	Upper
THOC2	Upper
ABBA	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	11 %	30 %
Height	Tree 0m	Tree 5m
Tree Size Class	Medium 9-21"DBH	

- [ ] Upper layer lifeform differs from dominant lifeform.

Description

Alvar galde (limestone- bedrock glade) phase: This is an herbaceous and graminoid dominated community with scattered clumps of stunted trees and shrubs. Tree cover >10%, shrub cover >25%. Dominant trees include white spruce (Picea glauca), paper birch (Betula papyrifera), northern white cedar (Thuja occidentalis) and balsam fir (Abies balsamea). Tree height is typically less than 20ft (6m). Common shrubs include soapberry (Shepherdia canadensis) and bearberry (Arctostaphylos uva-ursi). Common herbs are Canada mayflower (Maianthemum canadense), wild strawberry (Fragaria virginiana), balsam ragwort (Senecio pauperculus), and large-leaved aster (Aster macrophyllus). Poverty grass (Danthonia spicata), slender wheat grass (Agropyron trachycaulum) and bracken fern (Pteridium aqualinum) are also common. (Albert 2006b).

Alvar glade develops in areas of greater soil development or better drainage than the alvar grassland community (class A). Succession from class A could result in the development of this class (alvar grassland succeeding to alvar glade) but the timescale for sufficient soil development is beyond the scope of this model. Therefore the transition to this phase was modeled using alternate succession. In class B seasonal flooding

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(spring) followed by summer drought was modeled as "optional 1" with a probability of occurring every two years but this may occur on an annual basis. Also replacement fires, modeled with a probability of occurring every 500yrs, would kill the scattered trees and shrubs of this stage and more the system back to class A (grassland). Native grazing by white-tailed deer would maintain this class by restricting tree development. This disturbance was modeled with the probability of occurring every 100yrs, although deer herbivory in alvar glades in much more prevalent currently than under pre-European conditions. Alternate succession, modeled with the probability of occurring every 1000yrs, would take the system from the alvar glade to the alvar woodland stage. Again woodland development would depend largely on amount of soil development over bedrock.

Areas of alvar pavement, or exposed bedrock, may also occur as small to large patches within an alvar glade.

Class C **15 %**

Late Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

THOC2	Upper
BEPA	Upper
PIGL	Upper
ABBA	Upper

Structure Data (for upper layer lifeform)

	Min	Max
Cover	61 %	100 %
Height	Tree 5.1m	Tree 25m
Tree Size Class	Large 21-33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Alvar woodland (closed forest over limestone bedrock) The species composition of this stage would be similar to the alvar glade but tree canopy would exceed 30% and groundcover would be patchy with a higher dominance of sedges and forbs.

A mixed fire, modeling with the probability of occurring every 500yrs would convert the woodland back to a glade stage (class B), a replacement fire, modeled at with the probability of occurring every 1000yrs would take the system back to a grassland (class A).

Class D **0 %**

[Not Used] [Not Used]

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☐ Tree

Fuel Model

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	Max
Cover	%	%
Height		
Tree Size Class		

☐ Upper layer lifeform differs from dominant lifeform.

Description

Class E **0 %**

[Not Used] [Not Used]

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☐ Tree

Fuel Model

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	Max
Cover	%	%
Height		
Tree Size Class		

☐ Upper layer lifeform differs from dominant lifeform.

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100-year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement seve

Description

Disturbances

Fire Regime Group:** V

Historical Fire Size (acres)

Avg 0
Min 0
Max 0

Sources of Fire Regime Data

- ☐ Literature
- ☐ Local Data
- ☐ Expert Estimate

Fire Intervals	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	434.8			0.0023	88
Mixed	3333			0.0003	11
Surface					
All Fires	384			0.00261	

Fire Intervals (FI):
Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inver of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- ☐ Insects/Disease
- ☐ Wind/Weather/Stress
- ☑ Native Grazing
- ☐ Competition
- ☑ Other (optional 1) spring flooding/summer drought
- ☐ Other (optional 2)

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LANDFIRE Biophysical Setting Model

Biophysical Setting 5014110 Great Lakes Wet-Mesic Lakeplain Prairie

☐ *This BPS is lumped with:*
☐ *This BPS is split into multiple models:*

General Information

Contributors (also see the Comments field **Date** 4/10/2007

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Modeler 3			**Reviewer**		

Vegetation Type
Wetlands/Riparian

Map Zone
50

Model Zone
☐ Alaska ☐ N-Cent.Rockies
☐ California ☐ Pacific Northwest
☐ Great Basin ☐ South Central
☑ Great Lakes ☐ Southeast
☐ Northeast ☐ S. Appalachians
☐ Northern Plains ☐ Southwest

Dominant Species*

SCHIZ4	PYVI
ANGE	LISP
PAVI2	OLOH
SONU2	PELA2

General Model Sources
☑ Literature
☑ Local Data
☑ Expert Estimate

Geographic Range
Lakeplain wet-mesic prairies occur along the glacial lakeplains of the Great Lakes, in southeastern WI, northeastern IL, northern IN, southern MI and northwestern OH, as well as in southern Ontario, Canada. In MI, lakeplain wet-mesic prairies are found in three regions: the southeast counties along Lake Erie, the Detroit River and Lake St. Clair; the Saginaw Bay Shoreline; and in Berrien and Allegan counties in the southwest. These correspond with LANDFIRE subsections 222Ua, 222Ue and 222Jb.

Biophysical Site Description
Lakeplain wet-mesic prairie is most commonly associated with inland portions of MI's lakeplains, but is also found along low beach ridges near the present Saginaw Bay shoreline. More specifically, 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 soils are sands, sandy loams, loams, or silty clays with poor to moderate water-retaining capacity. Lakeplain prairies most commonly occur on sand lakeplain with soils of medium to fine-textured sands that are slightly acid to moderately alkaline (pH6-8). The prairies, which experience seasonal flooding and typically include small pockets that remain wet throughout the year, are among the most diverse plant communities in Michigan, with as many as 200 plant species found within a single prairie remnant.

Vegetation Description
The dominant tallgrass-prairie species of this community typically grow 1-2m high. Trees and shrubs are uncommon and bare ground is scarce. Andropogon gerardii (big bluestem), Carex (sedge) spp., Panicum virgatum (switch grass), Schizachyrium scoparius (little bluestem) and Sorghastrum nutans (Indian grass) are the most abundant species. Solidago ohioensis (Ohio goldenrod) is found in both fens and Great Lakes interdunal wetlands as well as this community. Pycnanthemum virginianum (common mountain mint) is

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common in this community but may also occur in woodlands. In addition to the species listed above, other diagnostic species include: Pedicularis lanceolata (swamp-betony), Solidago riddellii (Riddell's goldenrod), and Vernonia (ironweed) spp. Sorghastrum nutans, Liatris spicata (marsh blazing star), Aletris farinosa (colic root) and Coreopsis tripteris (tall coreopsis) are good indicators of functioning lakeplain wet-mesic prairie.

Rare plants associated with lakeplain wet-mesic prairie include: Agalinis gattingeri (Gattinger's gerardia), Agalinis skinneriana (Skinner's gerardia), Angelica venenosa (hairy angelica), Aristida longispica (three-awned grass), Asclepias hirtella (tall green milkweed), A. sullivantii (Sullivant's milkweed), Astragalus neglectus (Cooper's milk-vetch), Baptisia leucophaea (creamy wild indigo), Cacalia plantaginea (prairie Indian-plantain), Carex festucacea (fescue sedge), Conobea multifida (conobea), Cyperus flavescens (yellow nut-grass), Cypripedium candidum (white lady's-slipper), Fimbristylis puberula (chestnut sedge), Hemicarpha micrantha (dwarf-bulrush), Hypericum gentianoides (gentian-leaved St. John's-wort), Juncus biflorus (two-flowered rush), Juncus brachycarpus (short-fruited rush), Lechea minor (least pinweed), Ludwigia alternifolia (seedbox), Lycopodium appressum (appressed bog clubmoss), Panicum leibergii (Leiberg's panic-grass), Platanthera ciliaris (yellow fringed orchid), Platanthera leucophaea (prairie fringed orchid), Polygala cruciata (cross-leaved milkwort), Pycnanthemum verticillatum (whorled mountain-mint), Rotala ramosior (tooth-cup), Scirpus clintonii (Clinton's bulrush), Scleria pauciflora (few-flowered nut-rush), Scleria triglomerata (tall nut-rush), Tradescantia virginiana (Virginia spiderwort) and Triplasis purpurea (sand grass).

Disturbance Description

Many factors influence the development and maintenance of prairies on MI's lakeplain. Hubbard (1888) speculated that the extensive wet prairies of Wayne and Monroe counties were the result of beaver activity prior to their localized extirpation by the fur trade. His view was based on communications with Native Americans and the prevalence of abandoned beaver dams on the flat lakeplain landscape. Other important factors probably include both soil moisture regimes and periodic wildfires. The combination of 1-3m of highly permeable sand over clay sets up a characteristic hydrological regime with spring flooding followed by drought conditions during the growing season. This characteristic water level fluctuation is common to nearly all extant examples of MI's lakeplain prairies, and is possibly the most significant physical process in their establishment and maintenance (Albert et al. 1996, Minc 1995). Such extreme variation in the soil moisture regime prevents woody vegetation from becoming established (Roberts et al. 1977, Hayes 1964). In addition to the dramatic seasonal fluctuations in surface and ground water levels, Great Lakes water level cycles also produce fluctuations in the water table of these prairies. Wet prairies originally occupied the position on the landscape between emergent marsh and adjacent uplands. Based on the original surveyors' notes from the Saginaw Bay shoreline, the boundary between prairie and marsh was not static, but moved inland or lakeward across the landscape, depending on the stage of the Great Lakes water-level cycle.

The combination of accumulation of organic material within these wetlands and drought conditions during the growing season made lakeplain prairies prone to wildfires, which limited the encroachment of woody vegetation. However, it remains unclear whether lighting strikes or Native American activities had a more significant role in the maintenance of lakeplain prairie (Faber-Langendoen & Maycock 1987, Hayes 1964). It is clear, however, that Native Americans utilized dune ridges on the lakeplain for settlements and trails (Comer et al. 1995a, Jones & Knapp 1972). As elsewhere in the state, it is quite likely that fires periodically resulted from this use, spreading to adjacent savanna and grassland. One indication of the significance of fire on the lakeplain is the fact that many of the historical oak savannas located along the beach ridges have become closed-canopy oak forests during the last century of fire suppression.

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Adjacency or Identification Concerns

Historically, these prairies occurred in complex mosaics with lakeplain oak openings, pin oak-swamp white oak sand flatwoods and elm-ash-maple swamps, all typical of poorly drained lakeplain. At the base of old beach ridges, lakeplain wet-mesic prairie presently occurs as a transition zone between lakeplain wet-prairie and lakeplain mesic prairie (Comer et al. 1995a).

Lakeplain prairies have been lost and degraded via conversion to agriculture, residential and industrial development, alterations of ground water hydrology, and fire suppression. The construction of extensive drainage networks to promote agriculture and residential development has lowered the water table in most of the historical range of lakeplain prairies. That and the suppression of natural and cultural fires has allowed the community to succeed to shrub and forest communities. Also alteration of natural hydrologic and fire regimes has allowed invasives species to invade lakeplain prairie remnants. Significant invasive species found in lakeplain wet-mesic prairies include Phragmites australis, Phalaris arundiancea and Lythrum salicaria. Of nearly 160,000ac (64,000ha) of lakeplain prairie in MI circa 1800 less than 0.5% remain today (Comer et al. 1995a and b).

Native Uncharacteristic Conditions

Scale Description

Patch size characteristics for this community are variable. Circa 1800 patch sizes of lakeplain prairie mosaics (including wet, wet-mesic and mesic sand prairies) in MI varied from <100ac to over 15,000ac (40-6000ha) (Comer et al. 1995b).

Issues/Problems

Comments

The text in the General Information Section of this model was copied from the Michigan Natural Features Inventory Abstract for Lakeplain Wet-Mesic Prairie by Dennis Albert and Michael Kost. See References section for complete citation and associated references.

Vegetation Classes

Class A **43 %**

Early Development 1 Open

Upper Layer Lifeform

- [x] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model

Indicator Species* and Canopy Position

TYLA	Low-Mid
CAREX	Lower
SPPE	Low-Mid
CACA4	Low-Mid

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	11 %	60 %
Height	Herb 0m	Herb >1.1m
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform.

Description

The canopy closure in this stage can range up to 100% but the maximum canopy closure was set at 60 to make this stage exclusive from stage B. In this stage there may be standing water at the soil surface for part of the year.

Emergent marsh/lakeplain wet-prairie class: This stage is dominated by species such Calamagrostis canadensis, Spartina pectinata, Juncus balticus, Carex stricta, Carex aquatilis, Carex pellita (sedge), Cladium mariscoides, Potentilla fruiticosa and Asclepias incarnata (swamp milkweed) and wetter portions would contain Alisma plantago-aquatica, Carex, Eleocharis, Glyceria borealis, Leersia, Lemna, Nuphar, Nymphaea,

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Polygonum, Pontederia cordata, Sagittaria, Scirpus, Sparganium, Spirodela, Typha, Wolffia and Zizania aquatica.

This stage would occur with fluctuating Great Lakes water levels. When Great Lakes water levels rise, areas of wet-mesic prairie (class B) near the Great Lakes would be inundated and species mix would shift to wet prairie and marsh speceis (class A). Conversely, when Great Lakes water levels decline, modeled as "optional 1" with a probability of occurring every 40yrs (0.025), class A would shift to class B. This probability is an estimate and large-scale (interannual) fluctuations in Great Lakes water levels are stochastic events and occur without regular periodicity. In the absence of disturbance the class A would remain as class A.

Class B **43 %**

Early Development 2 Open

Upper Layer Lifeform

- [x] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model

Indicator Species* and Canopy Position

SCHIZ4	Low-Mid
SONU2	Low-Mid
PYVI	Lower
LISP	Lower

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	61 %	100 %
Height	Herb 0m	Herb 10.0m
Tree Size Class	None	

[ ] Upper layer lifeform differs from dominant lifeform.

Description

Lakeplain wet-mesic prairie class. The stage ranges from 0-100yrs, but lakeplain wet-mesic prairie systems can persist on the landscape for longer than 100yrs as long as fire and hydrologic regimes remain unaltered. This stage is dominated by Schizachyrium scoparius, Sorghastrum nutans, Panicum virgatum, and Andropogon geradii with forbs such as Pycnanthemum virginianum, Solidgao ohioensis, Liatris spicata, Pedicularis lanceolata, Solidago riddellii, Vernonia spp., and Coreopsis tripteris.

The poor to moderately drained soils of the lakeplain supports a moisture regime of spring flooding followed by summer drought. These edaphic factors maintain lakeplain prairie species and limits the encroachment of woody vegetation. In addition to abiotic and edaphic factors, fire also maintians the system in this class. Replacement fire was modeled with a probability of occurring every 7.5yrs (.15). The frequency of fires would have depended in large part on the concentration of Native Americans in the region.

For lakeplain wet-mesic prairies that occur near the Great Lakes, rises in Great Lakes water levels can send the system back to class A, a wet-prairie or marsh. This was modeled as "optional 2" at a probability of occurring every 40yrs (0.25). Again, this probability is an estimate and large-scale (interannual) fluctuations in Great Lakes water levels are stochastic events and occur with no regular periodicity.

With time and the absence of fires, trees and shrubs would establish and the system would transition to a lakeplain oak savanna/ oak woodland (class C).

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Class C 14 %

Late Development 1 Closed

Indicator Species* and Canopy Position

QUBI	Low-Mid
QUPA2	Low-Mid
ULAM	Lower
FRQU	Lower

Structure Data (for upper layer lifeform)

	Min	Max
Cover	31 %	90 %
Height	Tree 0m	Tree 25m
Tree Size Class	Large 21-33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Description

Lakeplain oak savanna/ oak woodland would include Querucs palustris, Q. bicolor, Ulmus americana and Fraxinus quadrangulata. This stage would result when trees encroach and establish in areas of lakeplain wet-mesic prairie. This would occur when frequent prairie fires are absent. Infrequent replacement fires, modeled at the probability of occurring every 150yrs (0.007) would take the system back to the wet-mesic prairie stage represented by class B. It is assumed that an area capable of supporting lakeplain oak savanna/woodland is far enough inland to no longer be affected by changes in Great Lakes water levels.

Class D 0 %

[Not Used] [Not Used]

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	Max
Cover	%	%
Height		
Tree Size Class		

☐ Upper layer lifeform differs from dominant lifeform.

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☐ Tree

Fuel Model

Description

Class E 0 %

[Not Used] [Not Used]

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	Max
Cover	%	%
Height		
Tree Size Class		

☐ Upper layer lifeform differs from dominant lifeform.

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☐ Tree

Fuel Model

Description

Disturbances

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Fire Regime Group:** II

Historical Fire Size (acres)

Avg 0
Min 0
Max 0

Sources of Fire Regime Data

- ☐ Literature
- ☐ Local Data
- ☐ Expert Estimate

Fire Intervals	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	15.29			0.0654	100
Mixed					
Surface					
All Fires	15			0.06542	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fir combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inver of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- ☐ Insects/Disease
- ☐ Native Grazing
- ☑ Other (optional 1) Decline in Great Lakes Water Levels
- ☐ Wind/Weather/Stress
- ☐ Competition
- ☑ Other (optional 2) Rise in Great Lakes Water Levels

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LANDFIRE Biophysical Setting Model

***Biophysical Setting* 5014120** **North-Central Interior Sand and Gravel Tallgrass Prairie**

☐ *This BPS is lumped with:*
☐ *This BPS is split into multiple models:*

General Information

Contributors (also see the Comments field **Date**

Modeler 1	John Harrington	jaharrin@wisc.edu	**Reviewer**	Doug Cox	mteecology@frontiernet.net
Modeler 2	Richard Henderson	Richard.Henderson@wisconsin.gov	**Reviewer**	Mike Kost	kostma@michigan.gov
Modeler 3			**Reviewer**	Becky Schillo	SchilloR@michigan.gov

Vegetation Type
Upland Grassland/Herbaceous

Map Zone
50

Model Zone
☐ Alaska ☐ N-Cent.Rockies
☐ California ☐ Pacific Northwest
☐ Great Basin ☐ South Central
☑ Great Lakes ☐ Southeast
☐ Northeast ☐ S. Appalachians
☐ Northern Plains ☐ Southwest

Dominant Species*
SCSC
SONU2
BOCU
HESP11

General Model Sources
☑ Literature
☐ Local Data
☑ Expert Estimate

Geographic Range

This BpS would have occurred in sections/subsections 222L (all-highest concentration would have been in this section), 222K(all), 222R(all), 251Ba and 222M (al). Largest expanse (11-13 million ha) of this type is found across Central Midwestern states with typical prairie border forests and prairie peninsula region of eastern states IA, MN, WI, IL, IN, KY and OH.

Biophysical Site Description

Within the area of the prairie border forests (Abrams 1992), prairie vegetation dominated the landscape with oak-hickory forests existing within fire-protected ravines or along stream corridors forming gallery forests (Abrams 1992). Our model abstracts prairie types to include xeric and dry-mesic types (Curtis 1959). Xeric prairies were maintained by shallow soils (less than four inches) on steep slopes (usually to the southwest) with extreme runoff of rainwater. Xeric prairies may also have occurred on flat uplands where soil is shallow and has low water holding capacity. In general these prairie types are found in both glaciated and non glaciated areas. They are excessively to well drained, with shallow depth to bedrock or sandy soils. Fertility ranges from poor acidic to richer neutral soils limited by moisture. Thin loess over bedrock is prevalent in western ranges of this type in Wisconsin. This type is most prevalent in driftless areas with sharper topography but also occurs in glaciated areas among glacial till and outwash and well-drained sand and gravel deposits Level sites occurred on glacial outwash with a very porous subsoil of sand and gravel. Rolling areas were characterized by glacial till of recessional moraines or on residual loess soils. While the region is strongly influenced by dry continental air flow patterns and periodic

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drought, historic fire frequency determined the prairie-forest boundary with much variation based on topography, fuel breaks, ignition sources, and climate (Anderson and Bowles 1999, Whitney 1994). Over time, forest edges expanded and contracted based on topographic variability and fire frequency and intensity exhibiting a continuum of grassland, "grub," open savanna woodlands or canopied forests. Much has been written concerning these systems and excellent reviews can be found in Curtis (1959), Whitney (1994) and Anderson, Fralish and Baskin (1999).

Vegetation Description

Grasses formed the matrix of the prairie with sideoats grama (Bouteloua curtipendula) and little bluestem (Schizachyrium scoparium) being the main indicator species. Big bluestem (Andropogon gerardii), Indian grass (Sorghastrum nutans), needlegrass (Hesperostipa spartea), and prairie dropseed (Sporobolus heterolepsis) also dominate many dry to dry-mesic prairies (Whitney 1994). Numerous forbs such as composites--Aster spp., Silphium spp., blazingstars (Liatris spp.) and coneflower (Echinaceas pallida), legumes--prairie clovers (Petalostemum spp.), roundheaded bushclover (Lespedeza capitata), and leadplant (Amorpha canescens) among many others, were also present. Fuel complexes consisted of short- or tall-grass prairie forbs and shrubs with little or no tree regeneration.
Oak grubs and shrubs characterize that portion of this vegetation sequence that experienced recurring fires in advanced oak regeneration, which stimulates the resprouting response evidenced by the 'grubs' or multi-stemmed stump sprouts of black oak (Q. velutina), bur oak (Q. macrocarpa), white oak (Q. alba) and others (Abrams 1992). Shrub species include New Jersey tea (Ceanothus americanus), hazelnut (Coylus, americana), gray dogwood (Cornus racemosa) and sumac (Rhus spp.). Over a period of years, massive root systems developed, and the term 'grub' (from the German gruben, 'to dig'), referenced the laborious method of removing these root wads in clearing areas for planting (Anderson and Bowles 1999). Fuel complexes were characterized as "stunted brush prairie" comprised of mixed prairie grasses and forbs with coppicing oak stems about 1-1.5m in height (Curtis 1959, Anderson and Bowles 1999).

Savannas and woodlands represent relatively open forest systems along the prairie-forest continuum (for extreme variety see Anderson et al. 1999). Generally, these systems have example species from true open prairies, woodlands, and closed canopy forests, with oak species dominating the arboreal layer (Abrams 1992). For the purposes of FRCC we have adopted fairly average canopy closure values o 0-10% closure for praire, 10-25% closure to indicate savanna, while woodlands exhibit 25-60% canopy closure (see discussion in Anderson and Bowles 1999 for variation across range).

Disturbance Description

Frequent fires impacted this prairie system every 1-5yrs, maintaining grass and forb vegetation. Insect and small mammal herbivory impacts composition and dominance (Howe et al 2006). Large mammals were present in low densities, main grazers were elk and deer with impacts likely being minimal.

Shrub and tree establishment and longevity was influenced by fire intensity and return interval.

Fire intensity will be influenced by topography, weather, productivity and aspect. For example, productive soils on level terrains supported more intensive fires and the areas with fire breaks or leeward sides/north-facing slopes generally supported more savanna types. Fire intensity varied based on humidity and temperature. Fire intensity also varies with aspect and slope. For example south and west facing steep slopes would have burned at a higher intensity resulting in few trees and shrubs.

Oak wilt occurred on sand prairies and likely resulted in mortality of larger oak groups especially when they occurred in high densities. This was not modeled due to the general lack of larger oak groups in this BpS.

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Diseases and insects can impact species composition. However, specific impacts are not clearly understood and therefore not modeled.

Within the western ranges of this type in WI and MN, there was a grazing and fire interaction. This was probably minimal in MZs 41, 50 and 51, since those are more eastern. As one moves east in this region fire increases to where it is the major disturbance factor for this type and grazing drops out as an influence.

Proximety of seed source is important to probability of shrub and tree invasion. Proximity is related to isolation of trees/ shrubs. Less edge equals lower probability of tree/shrub invasion.

Health and vigor of the sod influences shrub/tree invasion. Better health of sod reduces probability of successful establishment of trees and shrubs.

Adjacency or Identification Concerns

North-central interior oak savanna, North-central oak barrens, central tallgrass prairie, and adjacent sedge meadows and wet prairie are the systems that would be adjacent to this BpS.

Synonymous local classifications include bluff prairie, hill prairie, sand prairie, limestone prairie and dry prairie.

This BpS might be confused with the central tallgrass prairie systems.

In the absence of historic fire invasive problems have increased dramatically, including eastern red cedar (Juniperus virginiana). Exotics that have become invasive due to agricultural pracitices and roadside plantings include leafy spurge (Euphorbia esula), knapweed, sweet clover (Melilotus alba), and crown vetch and birds foot trefoil. Domestic livestock grazing is also an issue.

Today this system has severely reduced native cover (approx. 99% loss) due to conversion to other uses such as agriculture. Altering of the type is due to grazing and reduced fire resulting in greater shrub and tree component (red cedar (Juniperus virginiana), oak species (Quercus spp.) and a variety of native and non-native shrubs, and non-native cool season grasses (brome, bluegrass, quackgrass and redtop) resulting in reduced diversity.

Agriculture on level sand prairie where irrigation will support crops is a type conversion that might be present today such that the historical condition is unidentifiable. Invasion of cool season grasses and shrubs often mask the identification of this type.

Again, species composition and structure was dependent on local factors such as topography, soil conditions, fire regime, plant competition and plant-animal interactions (Anderson and Bowles 1999).

Native Uncharacteristic Conditions

Many small trees and shrubs would be uncharacteristic of this system historically but occurs today due to the lack of fire. Domestic livestock grazing has eliminated many native species and has altered species composition. There is not much of the grassy stages left due to altered fire regimes and with grazing the species have shifted.

Scale Description

Within regions of varied topography, type patches are typically small (<200ac) limited by topography, but

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in regions of level topography on extensive sands and gravel deposits these could be much larger.

Issues/Problems

The plant/animal interactions are not fully understood for this model and numerous studies of these phenomena are ongoing. Research exists for bison/fire interaction in detail. Also, there is possible overlap with the North-Central Interior Oak Savanna model. There is variation in oak species composition across the broad region covered by this model (i.e., bur oak [Quercus macrocarpa] occurs in the western portion of the range).

There is also great variation in prairie type across the Great Lakes region (MZs 41, 50 and 51). For instance, within the western ranges of this type in WI and MN, there was an interaction between grazing and fire disturbances. This was probably minimal in MZs 41 and 50 since those are more eastern. As one moves east in this region fire increases to where it is the major disturbance factor for this type and grazing drops out as an influence. Also, the species composition also changes from east to west; therefore, this is hard to model as one type.

For all oak systems, oak wilt is becoming more wide-spread due to an increased number of mature oaks and the amount of wood being moved around.

Comments

Additional review was provided by Tim Christiansen (tim.christiansen@us.army.mil). Model was reviewed at the Vegetation Modeling Workshop by Elena Conteras, Randy Swaty, Mike Kost, Chris Weber, Doug Cox and Becky Schillo.

This model for Great Lakes was adapted from the Rapid Assessment model R6BSOH Mosaic of Bluestem Prairie and Oak-Hickory created by C Emanuel cemanuel@tnc.org, S Hickey shickey@tnc.org, D. Minney dminney@tnc.org.

This model for the Rapid Assessment was created 5/26/04 for the Fire Regime Condition Class (FRCC) Interagency Handbook. An additional modeler was involved in this process, Charles Ruffner. The original document was coded BLST1 and then subsequently BLST2 for the FRCC code. The original model was altered in the Rapid Assessment Workshop (1/24/05) by Todd Hawbaker (tjhawbaker@wisc.edu) and Tricia Knoot (tknoot@iastate.edu). Please see RA model for details about class percentages changed and altered.

Vegetation Classes

Class A 82 %

Early Development 1 Open

Upper Layer Lifeform

- [x] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model 3

Description

Indicator Species* and Canopy Position

SCSC	Upper
SONU2	Upper
BOCU	Upper
HESP11	Upper

Structure Data (for upper layer lifeform)

	Min	Max
Cover	61 %	100 %
Height	Herb 0m	Herb >1.1m
Tree Size Class		

- [ ] Upper layer lifeform differs from dominant lifeform.

Additional species include prairie dropseed and big bluestem.

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100-year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement seve

Grasses formed the matrix of the prairie with big bluestem (Andropogon gerardii), Indian grass (Sorghastrum nutans), little bluestem (Schizachyrium scoparium), needlegrass (Hesperostipa spartea), prairie dropseed (Sporobolus heterolepsis) and sideoats grama (Bouteloua curtipendula) dominating many dry to dry-mesic prairies (Whitney 1994). Numerous forbs such as composites--Aster spp., Silphium spp., blazingstars (Liatris spp.) and coneflower (Echinaceas pallida), legumes--prairie clovers (Petalostemum spp.), roundheaded bushclover (Lespedeza capitata), and leadplant (Amorpha canescens) among many others, were also present. Fuel complexes consisted of short- or tall-grass prairie forbs and shrubs with little or no tree regeneration. Fuel complexes consisted of short- or tall-grass prairie forbs.

Replacement fires occur frequently in early successional seral class A (modeled at the probability of occurring every 3-4yrs) and maintain the system in class A. Grass cover in this stage truly should be in the high cover ranges. If it were lower, it would be a different area/system.

This class would go to class B if fire and seed source were unavailable (modeled as alternate succession at a 0.008 probability or the probability of occurring every 130yrs). We would like to model this as time since disturbance without a probability; however, that's unallowable. So - we just modeled with a probability. Also distance to seed (from birds, wind, small mammals) would influence whether we get to B or not without fire.

Small mammals and invertebrates and tree pathogens such as oak wilt probably occurred historically, but unsure of impact, so they were not modeled.

This A class is the grass type and was very common historically, but not currently.

Class B **15 %**

Mid Development 1 All Structures

Upper Layer Lifeform

- ☐ Herbaceous
- ☑ Shrub
- ☐ Tree

Fuel Model 1

Indicator Species* and Canopy Position

BOCU	Low-Mid
SCSC	Middle
COAM3	Upper
CORA6	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	11 %	50 %
Height	Shrub 0m	Shrub 30.0m
Tree Size Class	Seedling <4.5ft	

☑ Upper layer lifeform differs from dominant lifeform.

Perennial grasses dominate this class with <50% oak/shrub canopy.

Description

This is the shrub-oak grub representing prairie with scattered shrub and seedling sprouts or grubs. This vegetation is experiencing recurring fires in advanced oak regeneration, which stimulates the resprouting grubs. Fuel complexes are characterized as "stunted brush prairie" comprised of mixed prairie grasses and forbs with shrubs and coppicing oak stems about 1-1.5m in height (Curtis 1959; Anderson and Bowles 1999).

This is the brush-phase that occurs without fire. A replacement fire, modeled with the probability of occurring every 25yrs, could take system back to class A. A replacement fire, modeled with the probability of occurring every 4 -5yrs would maintain the system in class B. If the system where to through a real drought then fire would be more effective in reducing the shrub component and sending the system back to class A. In an average year, fire would set back shrub growth but they would resprout. There would have to be the right conditions of drought and fire to truly set the system back to class A. Also, it would have to be a very intense frequent fire to take this class back to A. However, if shrubs are just starting to come in, it might be easier to get back to A.

Fire frequency in general is the same as class A, but the intensity and right site conditions is what would

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transition this stage back to A.

Severe drought cycles, modeled as a wind/weather/stress event, occur approximately every 30-ish years. Therefore, if we get enough fire around these drought events, the fire might take this stage back to A - especially if shrubs are in the beginning stage - if lower canopy cover, would go back to A. It's questionable as to whether or not a filled-up-shrub stage would go all the way back to A, might just set back a bit. Fire modeled as having the ability to take back to A with 0.017 probability.
It is questionable as to whether this stage is truly part of this system or whether it's transitioned to another type.

B can go to C, modeled through alternate succession if there is a seed source combined with weather conditions and lack of fire. Therefore it was modeled with a probability of 0.010 or of occurring every 100yrs.

Surface fires are possible in this stage, because as the shrubs get taller, it's surface fire that will creep along the grass and not topkill the shrubs. As we get more surface fire, this class actually moves to C.

Class C **3 %**

Mid Development 2 All Structures

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 1

Indicator Species* and Canopy Position

BOCU	Lower
COAM3	Middle
QUERC	Upper
SCSC	Low-Mid

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	11 %	20 %
Height	Tree 0m	Tree 10m
Tree Size Class	Pole 5-9" DBH	

☑ Upper layer lifeform differs from dominant lifeform.

Perennial grasses dominate this class with a 11% maximum tree canopy-LANDFIRE rules made us up the maximum to 20%. Above this percent, this system often moves to north-central oak savanna. Juniperus virginiana is also a prominent small tree on the driest prairies.

Description

This box would rarely occur, and would not ever come back to prairie unless there is a catastrophic fire with high intensity, or having extremely intense fires successively, or time of year/seasonality could influence going back to A, which might have occurred but very infrequently. Replacement fire, modeled with the probability of occurring every 200yrs, could take the class back to class A. C class is more common today, but not historically.

Fuel complexes for savanna areas were largely prairie grasses and forbs in the understory with widely scattered fire-resistant shrub and oak stems forming the overstory.

After 20% cover, this goes into other system.

Class C would have surface fires because it's a tree/shrub system which won't get topkilled.

Replacement fires could happen under the right conditions to take it all the way back to A, but would be very unlikely. Replacement fires, modeled at the probability of occurring every 25yrs, could also take this class

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back to B under the right conditions. This would happen when there is enough fire intensity to top kill the trees, but not enough successive fires to take this box back to all grass (box A).

Drought would increase the fire effect in this class.

Class D 0 %

[Not Used] [Not Used]

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☐ Tree

Fuel Model

Description

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	Max
Cover	%	%
Height		
Tree Size Class		

☐ Upper layer lifeform differs from dominant lifeform.

Class E 0 %

[Not Used] [Not Used]

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☐ Tree

Fuel Model

Description

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	Max
Cover	%	%
Height		
Tree Size Class		

☐ Upper layer lifeform differs from dominant lifeform.

Disturbances

Fire Regime Group: II**

Historical Fire Size (acres)

Avg 200
Min 1
Max 2000

Sources of Fire Regime Data

- ☐ Literature
- ☐ Local Data
- ☑ Expert Estimate

Fire Intervals

	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	3.610	1	8	0.277	96
Mixed					
Surface	90			0.01111	4
All Fires	3			0.28812	

Fire Intervals (FI):
Fire interval is expressed in years for each fire severity class and for all types of fir combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inver of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- ☐ Insects/Disease
- ☑ Wind/Weather/Stress
- ☐ Native Grazing
- ☐ Competition
- ☐ Other (optional 1)
- ☐ Other (optional 2)

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100-year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement seve

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*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100-year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement seve

LANDFIRE Biophysical Setting Model

Biophysical Setting 5014210 Central Tallgrass Prairie

☑ *This BPS is lumped with: 1488 and 1420*
☐ *This BPS is split into multiple models:*

General Information

Contributors (also see the Comments field **Date**

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Vegetation Type
Upland Grassland/Herbaceous

Map Zone
50

Model Zone
☐ Alaska ☐ N-Cent.Rockies
☐ California ☐ Pacific Northwest
☐ Great Basin ☐ South Central
☑ Great Lakes ☐ Southeast
☐ Northeast ☐ S. Appalachians
☐ Northern Plains ☐ Southwest

Dominant Species*
ANGE
SONU2
SPHE
SPPE

General Model Sources
☑ Literature
☐ Local Data
☑ Expert Estimate

Geographic Range

Central tallgrass prairie is found in sections 222Ma, 222Mb, 222Na, 222L, 222K and 222Jb, Jh and Ji, 251 Ba and 251 Aa. This type is found across central midwestern states with typical prairie border forests and prairie peninsula region of eastern states IA, northwest MO, MN, WI, IL, IN, KY and OH. The system interfaces and mingles on the east with the oak savanna and on the west with mixed grass prairie. It is distributed with north central sand and gravel tallgrass which represents the dry prairie segment.

Biophysical Site Description

Within the area of the prairie forder forests (Abrams 1992), prairie vegetation dominated the landscape with oak-hickory forests existing within fire-protected ravines or along stream corridors forming gallery forests (Abrams 1992). While the region is strongly influenced by dry continental air flow patterns and periodic drought, historic fire frequency determined the prairie-forest boundary with much variation based on topography, fuel breaks, ignition sources and climate (Whitney 1994, Anderson and Bowles 1999). Much has been written concerning these systems and excellent reviews can be found in Curtis (1959), Whitney (1994) and Anderson, Fralish and Baskin (1999). The area is primarily mollic grassland soils incorporating mesic and hydric prairie types (Curtis 1959). Mesic prairies occurred on flat and rolling topography including some on glacial outwash with porous subsoil of sand and gravel. Rolling areas were characterized by glacial till of recessional moraines or on residual aeolian loess deposits. Soil profiles consist of a black surface layer rich in organic material with high water-holding capacity. Wet prairies were found on poorly drained soils in drainage ways and concave positions on uplands an din lowlands along waterways or in areas subject to inundation. Lowland prairies were in and along

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waterways or in areas subject to frequent inundation. Soils are rich in organic matter and show evidence of inundation in a gleying layer 3-4ft below the surface. The region is strongly influenced by dry continental air flow patterns and periodic drought (Whitney 1994).

Vegetation Description

Dominated by big bluestem (Andropogon gerardii), Indiangrass (Sorghastrum nutans) and prairie dropseed (Sporobolus heterolepsis) on more mesic sites with prairie cordgrass (Spartina pectinata) and bluejoint grass dominating the wet sites. Secondary species such as little bluestem (Schizachyrium scoparium) and porcupine grass (Stipa spartea) occupied the drier portions of these uplands and soil types and varied in importance. Forb families had their largest representation in Aster and legume. Conspicuous perennial forbs included the genera Asclepias, Aster, Echinacea, Helianthus, Solidago, Liatris, Dalea, and Viola. Prairie shrubs include the genera Amorpha, Rosa spp. and Ceanothus.

Disturbance Description

Frequent fires impacted this prairie system every 1-3yrs, maintaining grass and forb vegetation. Insect and small mammal herbivory impacts composition and dominance. Large mammals were present in low densities, main grazers were elk and deer, but impacts were likely minimal. Fire played an important role in the maintenance of the tallgrass prairie (Curtis 1959, Vogl 1964, Anderson 1990). Fire could occur throughout the year with larger, less frequent fires occurring during the dormant season and smaller, more frequent fires occurring during the growing season. Native American burning, essential to maintaining the eastern tallgrass prairie, was bimodal in distribution, peaking in April and October with lightning ignition occurring primarily during July and August (Higgins 1986). Bison grazing as a major disturbance was likely much more limited than prairies further west. Elk probably contributed to the impact of grazing and browsing as well but it is assumed that the total contributions of these two species was still considerably less than to the west. The elk may have contributed to the reduction of young woody saplings invading prairie adjacent to protected woody areas.

Ortmann in his review suggested that in addition to fire, drought and grazing, insect outbreaks would have impacted all classes.

Drought would have set back woody species invasion and would have increased fire intensity. Lack of winter snowfall would have also reduced woody species due to desiccation of soils.

Adjacency or Identification Concerns

Central tallgrass prairie would be adjacent to north-central interior oak savanna, north-central oak barrens, north central interior sand and gravel prairie, and sedge meadows and wet prairie.

Synonymous names for this system include: mesic prairie, wet prairie, deep soil prairie and blacksoil prairie.

This BpS might be confused with the north central interior sand and gravel prairie.

In the absence of historic fire invasive problems have increased dramatically, including gray dogwood, American plum and hazelnut. Exotics that have become invasive due to agricultural practices and roadside plantings include reed canary grass, leafy spurge (Euphorbia esula), sweet clover (Melilotus alba), crown vetch, yellow parsnip and birds foot trefoil. Domestic livestock grazing is also an issue.

Today this system has a severely reduced native cover (approx. 99.9% loss) particularly for the mesic component of this type due to conversion to other uses such as agriculture. In addition to the massive

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reduction in extent of mesic prairie, the scale of its occurrence has also severely been altered. Currently this type occurs in fragmented small patches ranging from 1-10ac. Altering of the type is due to grazing and reduced fire resulting in greater shrub and tree component and a variety of native and non-native shrubs, and non-native cool season grasses (brome, bluegrass, quackgrass and redtop) resulting in reduced diversity.

This system has mainly been converted to agriculture and other development. Invasion of cool season grasses and shrubs often mask the identification of this type. It may be difficult to determine the difference between old fields and native prairie patches by using aerial photos or remote sensing data.

Again, species composition and structure were dependent on local factors such as topography, soil conditions, fire regime, plant competition, and plant-animal interactions (Anderson and Bowles 1999).-

As indicated this system interfaces and mingles on the east with oak savanna and on the west with mixed grass prairie (in NE and the Dakotas). On the east there would be limited woody invasion from protected areas during periods of increased precipitation. The woody component would be limited to the edge the prairie and would not exhibit any appreciable effect overall. Since mixed grass prairie is to the west, there would be little effect except in periods of extended drought the percentage of the mixed grass species would increase.

This system differs functionally from North-Central Interior Sand and Gravel Tallgrass prairie due to fire intensity - heavier fuels leading to higher fire intensity and a stronger grass competition for trees and shrubs to come in; so it's more difficult for trees and shrubs to come into this system.

Native Uncharacteristic Conditions

Many small trees and shrubs would be uncharacteristic of this system historically but occurs today due to the lack of fire. Domestic livestock grazing has also severely degraded this system. Haying would also have altered the species composition, especially for forbs species. Insects may not be as prevalent in modern times due to fragmentation (hypothesis by Tim Christiansen, pers. comm.).

Scale Description

Within regions of varied topography, type patches are typically large (>1000ac) most prevalent on flat to rolling topography. Most fires were stand replacement in nature. Once ignited, dormant season fires would have spread over a large area until reaching a major firebreak (e.g. previously burned area, major river, rugged terrain, etc.). Growing season fires may have been frequent but smaller in size than dormant season fires due to the greenness of the fuel and rain following lightning ignition. Growing season fires during drought years would have been much like dormant season fires. Mixed fires were probably limited to patchy grazed areas or areas where fuel was not uniformly cured.

Issues/Problems

The plant/animal interactions are not fully understood for this model and numerous studies of these phenomena are ongoing. Research exists for bison/fire interaction in detail in the western range of this system (i.e. Kansas and Nebraska). Also, there is possible overlap with the North Central Interior Oak Savanna model (BpS ID 1394, MZs 41, 50 and 51). There is variation in oak species composition across the broad region covered by this model (i.e., bur oak [Quercus macrocarpa] increases in prevalence in the western portion of the range). There is also great variation in prairie type across this region. Within the western ranges of this type there was a grazing and fire interaction. As one moves east in this region fire increases to where it is the major disturbance factor for this type and grazing drops out as an influence.

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The species composition also changes from east to west. Much of the literature on fire in the tallgrass prairie does not include interaction with herbivory (Engle and Bidwell 2001) thus interpreting effects must be qualified. In addition, little is know about native ungulate grazing in this area. It is generally accepted that bison grazing was less in this grassland than in grasslands to the west. Even within this type grazing likely played a larger role as one moves from east to west. Further, it has been recently suggested that elk populations may have been large enough to have an effect on vegetative composition. Some woody plant invasion may have occurred but it was limited to areas close to seed sources such as along the eastern interface with the savanna and around woody pockets and river valleys.

Comments

Suggested reviewers: Dave Borneman, see also sand and gravel parried reviewers. This model was reviewed at the LANDFIRE Vegetation Modeling Workshop by Elena Conteras, Randy Swaty, Mike Kost, Chris Weber, Doug Cox and Becky Schillo.

This model for Great Lakes was adapted from the Rapid Assessment model R4PRTGc Tallgrass Prairie - Central created by Daryl Smith daryl.smith@uni.edu and reviewed by Tom Bragg tom.bragg@mail.unomaha.edu and John Ortmann jortmann@tnc.org and an anonymous reviewer.

Vegetation Classes

Class A **40 %**

Early Development 1 Open

Upper Layer Lifeform

- [x] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model 3

Indicator Species* and Canopy Position

ANGE	Upper
SONU2	Upper
SPPE	Upper
SPHE	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	70 %
Height	Herb 0m	Herb >1.1m
Tree Size Class		

- [ ] Upper layer lifeform differs from dominant lifeform.

Open refers to absence of tree or shrub canopy cover.

Description

Post Fire Regrowth Stage - Duration: one year. From blackened state, rapid regrowth of fire positive and fire neutral perennial vegetation to maximum height by end of growing season. Warm season grasses and fire positive forbs display increased height, flowering and fruiting and appear to be more abundant depending on season of the burn. Annual, biennial and short-lived perennial species occupy space opened by litter removal. Fire neutral perennial forbs maintain pre-fire composition, but may appear to be reduced. Fire negative species are reduced. No litter accumulation in this class. Probability of a replacement fire is 1.00 as all surface fires are replacement in this system.

The cover in this class is defined as 0-70% for mapping purposes. However, it could really go up to 100% cover.

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Class B 59 %

Mid Development 1 Open

Upper Layer Lifeform

- [x] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model 3

Indicator Species* and Canopy Position

ANGE	Upper
SONU2	Upper
SPPE	Upper
SPHE	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	71 %	100 %
Height	Herb 0m	Herb >1.1m
Tree Size Class		

- [ ] Upper layer lifeform differs from dominant lifeform.

SPHE refers to Sporobolus heterolepsis

Description

Unburned Stage - Duration: 2-4yrs. This unburned stage continues to be dominated by big bluestem (Andropogon gerardii), Indiangrass (Sorghastrum nutans) and prairie dropseed on more mesic sites with prairie cordgrass (Spartina pectinata) and bluejoint grass dominating the wet sites. Secondary species such as little bluestem (Schizachyrium scoparium) and porcupine grass (Stipa spartea) occupied the drier portions of these uplands and soil types and varied in importance. Perennial forbs include genera such as Asclepias, Aster, Echinacea, Helianthus, Solidago, Liatris, Dalea, and Viola. Noticeable scattered shrubs, Amorpha, Rosa spp and Coenothus, annually increase in size. Litter accumulates annually. Annuals, biennials and short lived perennials gradually become less abundant.

Probability of a replacement fire is 0.33. If it's a cool fire, and intensity is low, it'll probably stay in B; won't remove all thatch and some shrubs will survive. However, with a lot of fuels, and if hot - could go all the way back to A. Without fire for about six years, sometimes it will move to C.

The cover in this class is defined for mapping purposes as 71-100%. Some shrubs might be coming up in this stage.

Class C 1 %

Late Development 1 All Structures

Upper Layer Lifeform

- [ ] Herbaceous
- [x] Shrub
- [ ] Tree

Fuel Model 3

Indicator Species* and Canopy Position

ANGE	Middle
SPPE	Middle
SALI	Upper
CORA6	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	30 %
Height	Shrub 0.6m	Shrub 30.0m
Tree Size Class		

- [ ] Upper layer lifeform differs from dominant lifeform.

SALI refers to Salix spp. Herbaceous layer is still dominant. But grass cover declining due to thatch; won't be as dense.

Description

Unburned Thatch Accumulation Stage - Duration 5-20yrs. Continuation of unburned state from class B, however, with lack of fire for the long term, the prairie matrix weakens and it is succeeded by woody cover of shrubs and trees, depending on proximity of woody seed sources. Without fire the length of this stage is dependent on ppt and temperature as well as topography and soils. It can be inferred that the effect of large ungulates, bison and elk, was highly limited in this region of this type. Probability of a replacement fire is 0.33 approximately.

As thatch builds up, grasses will start to lose vigor and become less competitive, and then shrubs or trees might start moving in more, which would be uncharacteristic, because that would be due in part to lack of fire.

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Class D 0 %

[Not Used] [Not Used]

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☐ Tree

Fuel Model

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	Max
Cover	%	%
Height		
Tree Size Class		

☐ Upper layer lifeform differs from dominant lifeform.

Description

Class E 0 %

[Not Used] [Not Used]

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☐ Tree

Fuel Model

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	Max
Cover	%	%
Height		
Tree Size Class		

☐ Upper layer lifeform differs from dominant lifeform.

Description

Disturbances

Fire Regime Group: II

Historical Fire Size (acres)

Avg 10000
Min 10
Max 100000

Sources of Fire Regime Data

- ☑ Literature
- ☐ Local Data
- ☑ Expert Estimate

Fire Intervals

	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	3.571	2	5	0.28	100
Mixed					
Surface					
All Fires	4			0.28002	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fir combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inver of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- ☐ Insects/Disease
- ☑ Wind/Weather/Stress
- ☐ Native Grazing
- ☐ Competition
- ☐ Other (optional 1)
- ☐ Other (optional 2)

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*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100-year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement seve

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LANDFIRE Biophysical Setting Model

Biophysical Setting 5014440 Eastern Boreal Floodplain

☐ *This BPS is lumped with:*
☐ *This BPS is split into multiple models:*

General Information

Contributors (also see the Comments field **Date** 4/11/2007

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Modeler 3			**Reviewer**		

Vegetation Type
Forest and Woodland

Map Zone
50

Model Zone
☐ Alaska ☐ N-Cent.Rockies
☐ California ☐ Pacific Northwest
☐ Great Basin ☐ South Central
☑ Great Lakes ☐ Southeast
☐ Northeast ☐ S. Appalachians
☐ Northern Plains ☐ Southwest

Dominant Species*
FRNI
POBA2

General Model Sources
☐ Literature
☐ Local Data
☑ Expert Estimate

Geographic Range
This system is largely found in eastern Canada with limited occurrences in northern MN, northern MI and northern ME.

Biophysical Site Description
River valleys are linear depressions that contain a river channel and its floodplain, often embedded within a series of higher terraces. River valleys, formed by the meltwater of glaciers, occur in glacial outwash channels. The river floodplain is the low-lying area adjacent to the river that was formed under the present drainage system and is subject to periodic flooding and cycles of erosion and deposition. In contrast, terraces are former floodplain surfaces at higher elevations than the floodplain that were abandoned when the river channel incised lower into the valley floor. Within the broader landscape, river valleys represent an unusually diverse mosaic of landforms, physical environmental factors, species and biological communities because of their abrupt environmental gradients and complex ecological processes (Naiman et al. 1993, Gregory et al. 1991, Brinson 1990). Floodplain forests occur along streams or rivers that are third order or greater (Strahler 1952).

Vegetation Description
This system includes floodplain forests dominated by black ash and balsam poplar as well as herbaceous sloughs and shrubby wetlands. Alders, dogwood, mountain maple, bluejoint, and sedges are common in the understory or in non-forested areas.

Disturbance Description
Floodplain systems are produced and maintained by active hydrologic and geomorphic processes such as channel meandering, sedimentation and erosion (Gregory, et al. 1991) caused by natural hydrological variation (Richter and Richter 2000). Regeneration of the dominant species (balsam poplar and black ash)

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100-year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement seve

is dependent on flooding and movement of river channels, which creates bare, moist soil needed for seedling establishment (Scott et al. 1997). Oxbow and slough development also influence the floodplain system and create variability in plant community composition. Deposits of sand and other sediments can create low ridges that influence vegetation establishment (Weaver 1960). The flood frequency in a given area is dependent upon its location on the floodplain, with upper terraces having infrequent flooding and scouring events, while the lower terraces nearest the river flood frequently. Scouring caused by ice jams during the winter, channel meandering, and oxbow and slough development greatly influence this system.

Adjacency or Identification Concerns

Native Uncharacteristic Conditions

Scale Description

Patches must be adequate in size to contain natural variation in vegetation and disturbance regime. This system is often widespread on medium or larger rivers and should be at least 0.5 miles long and 100m wide.

Issues/Problems

Assumptions: This system is most affected by flooding, scouring and channel movement. We modeled the floodplain valley including forested and non-forested areas. The model does include wetlands, sloughs or oxbows. We used two flooding regimes in the model: Option 1 – minor flooding/scouring (2-20yr frequency); and Option 2 – major flooding/scouring (20-100yr frequency). Flood frequency for a class is based on location on the floodplain, with higher terraces being subject to longer flood cycles (up to 100yrs). We modeled attributes such as channel migration, oxbow and slough development and sedimentation. Fire activity had a minor impact, due to low intensity, infrequent intervals, small size and low fuel loads.

Comments

This model adapted from Rapid Assessment model R6FPFOgl Great Lakes Floodplain Forest by Robert Mayer (rmayer@fs.fed.us) and Rick Miller (rick.miller@dnr.state.oh.us) on 09/30/2005. Material from the MNFI community abstract for Floodplains (Tepley et al 2004) is also incorporated.

Vegetation Classes

Class A 15 %

Early Development 1 All Structure

Indicator Species* and Canopy Position

ALIN2	Upper
COSE16	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	51 %	90 %
Height	Shrub 0.6m	Shrub 30.0m
Tree Size Class	Seedling <4.5ft	

☐ Upper layer lifeform differs from dominant lifeform.

Upper Layer Lifeform

- ☐ Herbaceous
- ☑ Shrub
- ☐ Tree

Fuel Model

Description

Primary successional stage after significant flooding/scouring events. This class is usually dominated by shrubs and small trees. Common canopy species include Alnus incana, Cornus sericea, Fraxinus nigra, Populus balsamifera, and sometimes Abies balsamea.

This class ranges from age 0-14yrs. This class succeeds to class B. Minor flooding/scouring, modeled as optional 1 with a probability of occurring every 40yrs, would take the system back to time zero. Infrequent

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surface fire, modeled with the probability of occurring every 200yrs, would also maintain this class.

Class B **35 %**

Mid Development 1 Open

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

POBA2	Upper
FRNI	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	51 %	100 %
Height	Tree 5.1m	Tree 10m
Tree Size Class	Sapling >4.5ft; <5"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Young forests after trees have become established and dominate most areas. Limited canopy diversity. Dominant trees are Populus balsamifera and Fraxinus nigra.

This class ranges from age 15-39yrs. This class succeeds to class C. Minor flooding/scouring, modeled as optional 1 with a probability of occurring every 50yrs, would maintain the system in this class. Major flooding/scouring, modeled as optional 2 with a probability of occurring every 40yrs would take the system back to class A. Infrequent mixed fire, modeled with the probability of occurring every 200yrs, would also maintain this class.

Class C **38 %**

Mid Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

FRNI	Upper
POBA2	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	61 %	80 %
Height	Tree 10.1m	Tree 25m
Tree Size Class	Medium 9-21"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Mature forests subject to moderately frequent long-term flooding. Dominant species are Fraxinus nigra and Populus balsamifera.

This class ranges from age 40-149yrs. This class succeeds to class D. Minor flooding/scouring, modeled as optional 1 with a probability of occurring every 4 years, would maintain the system in this class. Major flooding/scouring, modeled as optional 2 with a probability of occurring every 40yrs would take the system back to class B. Surface fire, modeled with the probability of occurring every 200yrs, would also maintain this class.

Class D **12 %**

Late Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 10

Indicator Species* and Canopy Position

ABBA	Upper
ACRU	Upper
PIMA	Upper
POBA2	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	81 %	100 %
Height	Tree 10.1m	Tree 50m
Tree Size Class	Large 21-33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

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Description

Forests in the floodplain that are very rarely subject to significant flooding. Diversity increases and mesic species increase in importance. Dominant species include Abies balsamea, Acer rubrum, Populus balsamifera, Picea mariana and Pinus strobus.

This class is age >150yrs. Major flooding/scouring, modeled as optional 2 with a probability of occurring every 200yrs would take the system back to class B. Surface fire, modeled with the probability of occurring every 200yrs, would maintain this class.

Class E **0 %**

[Not Used] [Not Used]

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☐ Tree

Fuel Model

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	%	%
Height		
Tree Size Class		

☐ Upper layer lifeform differs from dominant lifeform.

Description

Disturbances

Fire Regime Group:** **III**

Historical Fire Size (acres)

Avg 3
Min 1
Max 35

Sources of Fire Regime Data

- ☐ Literature
- ☐ Local Data
- ☑ Expert Estimate

Fire Intervals	*Avg FI*	*Min FI*	*Max FI*	*Probability*	*Percent of All Fires*
Replacement					
Mixed	550			0.00182	35
Surface	300			0.00333	65
All Fires	194			0.00516	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fir combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inver of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- ☐ Insects/Disease
- ☐ Wind/Weather/Stress
- ☐ Native Grazing
- ☐ Competition
- ☑ Other (optional 1) Minor Flooding 5-20yrs.
- ☑ Other (optional 2) Minor Flooding 20-500 yr.

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LANDFIRE Biophysical Setting Model

Biophysical Setting 5014660 Great Lakes Wooded Dune and Swale

☐ *This BPS is lumped with:*
☐ *This BPS is split into multiple models:*

General Information

Contributors (also see the Comments field **Date** 5/24/2007

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Modeler 3			**Reviewer**		

Vegetation Type
Wetlands/Riparian

Map Zone
50

Model Zone
☐ Alaska ☐ N-Cent.Rockies
☐ California ☐ Pacific Northwest
☐ Great Basin ☐ South Central
☑ Great Lakes ☐ Southeast
☐ Northeast ☐ S. Appalachians
☐ Northern Plains ☐ Southwest

Dominant Species*

AMBR	PIRE
CALO	PIST
JUNCU	THOC2
PIBA2	ELAC

General Model Sources
☑ Literature
☑ Local Data
☑ Expert Estimate

Geographic Range

Great Lakes Wooded Dune and Swale complexes are found along the Great Lakes in Ontario, MI, WI, IL, IN, OH and PA. Of the 90-95 wooded dune and swale complexes that occurred in the Great Lakes Region, 70 were located in MI along the shores of Huron, MI, and Superior (Comer and Albert 1993). In MI wooded dune and swales are be found in subsections 212 S (all subsections), 212 R (all subsections), 212 Hl, 212 Hf, 212 Hb, 212 Hj, 212 Hg, 222 Ue and 222 Ud.

For MN this BpS occurred in subsection 212Lb.

Biophysical Site Description

This complex of wetland swales and upland beach ridges (dunes) is found in embayments and on large sand spits along the shoreline of the Great Lakes. Many complexes began forming when the Great Lakes were at glacial Lake Algonquin levels, approximately 12,000yrs ago (Comer and Albert 1993, Dorr and Eschman 1970), but in the southern Great Lakes, some of the large complexes are younger, approximately 6000yrs old (Chrzastowski and Thompson 1992, Thompson 1992). Receding lake levels deposited a series of sandy beach ridges ranging from 0.5 m to 40.0m high. From the air, these ridges appear as a series of arcs generally parallel to the shoreline, and often extending up to two miles inland. The dune ridges can be quite numerous, with 150 ridges forming over 6000yrs near Gary, Indiana (Thompson 1992) and 108 ridges forming over 3500yrs in northern lower MI (Lichter 1998). [Text from Albert, D.A. and P.J. Comer. 1999.]

Vegetation Description

Because it contains a unique assemblage of physiographic, soil, and vegetative components, and provides a high quality habitat for numerous shoreline animal species, the Wooded Dune and Swale Complex is considered a distinct natural community in MI (MNFI 1990). Classic ecological studies have identified

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distinctive successional zones within the sand dune portion of the complexes, determined on the basis of several factors, including distance from the lake, amount of soil development, and available light (Olson 1958, Cowles 1899).

The foredunes of most dune and swale complexes are commonly 1-2m high, with beach grass (Ammophila breviligulata), dune grass (Calamovilfa longifolia), autumn willow (Salix serissima), dune willow (S. cordata) and balsam poplar (Populus balsamifera) most common. Within their ranges, federally-threatened Pitcher's thistle (Cirsium pitcheri) and state-threatened Lake Huron tansy (Tanacetum huronense) are also found on the foredunes.

Immediately behind the foredune, where lake-influenced, calcareous sands are most common, a shallow swale often contains twig-rush (Cladium mariscoides), sweet gale (Myrica gale), shrubby cinquefoil (Potentilla fruticosa), blue joint grass (Calamagrostis canadensis), Kalm's lobelia (Lobelia kalmii), false asphodel (Tofieldia glutinosa), and grass-of-Parnassus (Parnassia glauca). Less commonly, in the Straits of Mackinac area, federally threatened Houghton's goldenrod (Solidago houghtonii) is found in the swales behind the foredune.

The swale immediately behind the foredune is influenced by short-term variation in lake levels and can be partially or occasionally completely filled by dune sands following major storm events. Species common to this first swale include the rushes (Juncus balticus, J. pelocarpus, J. Nodosus), spike rush, (Eleocharis acicularis) and threesquare (Scirpus americanus).

A low dune field with more advanced plant succession often follows the first open dunes and swales. Jack pine (Pinus banksiana), white pine (P. strobus), and red pine (P. Resinosa) often form a scattered overstory canopy, while ground juniper (Juniperus communis), creeping juniper (J. Horizontalis), bearberry (Arctostaphylos uva-ursi), beach grass and June grass (Koeleria macrantha) form a scattered ground layer.

Following the dune-field zone, both dunes and swales are typically forested. Moist swales are often forested and soil organic material has often begun to accumulate. Northern white cedar (Thuja occidentalis), speckled alder (Alnus rugosa), willows (Salix spp.) and red maple (Acer rubrum) dominate the partial overstory canopy and understory. In northern Lake Michigan and Lake Huron, where these swales are better drained, and northern white cedar forms the overstory, federally-threatened dwarf lake iris (Iris lacustris) may be found in large non-flowering populations. In contrast to the dry or moist swales, in those swales where standing water is present through most of the year, sedges (Carex aquatilis) and (C. stricta), twigrush, marsh marigold (Caltha palustris), swamp candles (Lysimachia terrestris) and swamp cinquefoil (Potentilla palustris) commonly dominate the ground layer.

Forested beach ridges, with soils of medium to course sand, tend to be dominated by species common to dry-mesic and mesic northern forest (MNFI 1990). Soil moisture conditions appear to change dramatically with slight elevational changes and are reflected in the development of soil organic material and changing plant species. On higher, drier ridges, soils often have less than three cm of organic material. Red pine, white pine and red oak (Quercus rubra) are often co-dominant, while paper birch (Betula papyrifera), bigtooth aspen (Populus grandidentata), balsam fir (Abies balsamea) and red maple are sub-dominant or understory species. Bracken fern (Pteridium aquilinum), black huckleberry (Gaylussacia baccata), blueberry (Vaccinium myrtilloides), bunchberry (Cornus canadensis) and wintergreen (Gaultheria procumbens) occur in the shrub and ground layers.

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On lower ridges, where soils are moister, soil organic material accumulation is greater (4-25cm). White pine may still dominate the overstory, but often white spruce, black spruce, red maple, balsam fir, northern white cedar and occasionally tamarack (Larix laricina) are co-dominant. Canada honeysuckle (Lonicera canadensis), mountain holly (Nemopanthus mucronatus), twinflower (Linnaea borealis), dwarf blackberry (Rubus pubescens), Canada mayflower (Maianthemum canadensis) and starflower (Trientalis borealis) are common in the shrub and ground layers.

Complexes located in embayments protected from prevailing winds tend to be formed entirely of low, water-lain beach ridges. As a result, even the beach ridges within these complexes support wetland vegetation. An example is Ogontz Bay, in the eastern Upper Peninsula of MI. Here swales ranged from 1-30m wide and 0.5-30.0m deep.

Narrow, shallow swales are forested with northern white cedar, black spruce, and red maple, with speckled alder and willows in the understory and shrub layers, and sedges
(Carex disperma), (C. trisperma), (C. leptalea), (C. Interior), (C. cryptolepis), (C. flava), (C. intumescens), blue joint grass, fowl manna grass (Glyceria striata), water horehound (Lycopus uniflorus) and Sphagnum mosses (Sphagnum spp.) in the ground layer.

Wider, deeper swales are more often unforested, with chokeberry (Aronia prunifolia), red osier dogwood (Cornus stolonifera), bog birch (Betula pumila), and speckled alder forming a shrubby ecotone, while sedges (Carex lasiocarpa), (C. oligosperma), (C. aquatilis), (C. Stricta), and woolgrass (Scirpus cyperinus) form a mat within which marsh fern (Thelypteris palustris) and horned bladderwort (Utricularia cornuta) also occur.
Where a sedge mat is not well developed, bur-reed (Sparganium minimum), pond-lily (Nuphar variegata), and pondweeds (Potamogeton berchtoldii and P. natans) are commonly found.

Organic material gradually accumulates in the swales over time; organic material in swales reaches a depth of 30-75cm within 300m of the lake's edge. Vegetation in swales reflects the more acid conditions of the older thickets as peat accumulations. Leatherleaf (Chamaedaphne calyculata), bog rosemary (Andromeda glaucophylla), Labrador tea (Ledum groenlandicum), bog laurel (Kalmia polifolia), large cranberry (Vaccinium macrocarpon), cottongrass (Eriophorum virginicum), pitcher-plant (Sarracenia purpurea) and Sphagnum mosses (Sphagnum centrale, S. wulfianum, S. warnstorfii, S. Magellanicum, and S. squarrosum) are commonly found in the thick peat soils of the swale behind the shoreline. An even stronger pattern of increased organic matter accumulation occurs farther north along Lake Superior. For example, at Grand Traverse Bay in Keweenaw County, very low beach ridges and swales have thick accumulation of acid organic matter, with bog-like vegetation in the first swale of the shoreline. [Text from Albert, D.A. and P.J. Comer. 1999.]

Disturbance Description

Natural processes: These complexes are best developed where streams provide a dependable sand source. The combination of along-shore currents, waves, and wind form foredunes along the shoreline. With gradual long-term drops in water level, combined with post-glacial uplifting of the earth's crust, these low dunes gradually rise above the direct influence of the lakes, and new foredunes replace them. Over several thousand years (far beyond the scope of this model), a series of ridges and swales is created. For most complexes, the flow of surface streams and groundwater maintain the wet conditions in the swales. Along the Lake Superior shoreline, where post-glacial uplift is greatest, many of the complexes consist primarily of dry, forested swales . The number and size of the dune ridges and swales differs depending on fetch and the amount of sediment available. (Comer and Albert 1993)

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Lichter's (1998) recent study of dune and swale complexes at Wilderness State Park in northern lower MI has identified similar successional trends. He found that, at the Lake Michigan shoreline, young dunes had 1) stronger winds, 2) more sand burial and erosion, 3) higher levels of sunlight, 4) higher rates of evaporation and 5) lower available nitrogen and phosphorus than older beach ridges farther inland, resulting in an open herbaceous-dominated plant community along the shore. Farther inland, with greater protection from sun and wind and with greater soil development, there was succession from open dune, first to grassland, then to shrubs, and finally to forests, with mesic northern hardwoods increasing in dominance on beach ridges farther from the shoreline.

Both swales and upland dune ridges were studied by MNFI (Comer and Albert 1991, 1993). Of the 17 sites where elevations were measured from the shoreline inland, only three sites contained swales where the sandy bottoms of all or most of the swales lay below the current Great Lakes water levels. This suggests that, except for a few examples, the influence of Great Lakes water-level fluctuations is probably limited to the first few swales inland from the shoreline. For most of the complexes, the water occupying the swales comes from streams flowing from the adjacent uplands or from groundwater seepage. [Text from Albert, D.A. and P.J. Comer. 1999.]

Adjacency or Identification Concerns

Many wooded dune and swale complexes have been destroyed, degraded and fragmented by anthropogenic disturbances. Protecting hydrology is important in the maintenance of vegetative structure in wooded dune and swale complexes. Road development across the swales, even with culverts, typically modifies the hydrology. Marinas, typically requiring dredging and other major modification of the wetlands, have been constructed in some complexes. Golf courses have also been built on complexes and unsuccessfully proposed for others. Intensive use as deer yards has greatly altered the wetlands in the Upper Peninsula, where regeneration of northern white cedar has been eliminated or greatly reduced. In some deer yarding areas, conversion of the ridges to aspen has also been proposed. Residential development has resulted in major alteration of several dune and swale complexes, due to several factors, including road and driveway construction, wetland filling, and septic leakage. Nutrient addition from leaking septic tanks and drain fields is suspected of contributing to the dominance of invasives such as Typha angustifolia (narrowleaved cat-tail), giant bulrush and purple loosestrife. [Text from Albert, D.A. and P.J. Comer. 1999.]

Native Uncharacteristic Conditions

Scale Description

This system is truly a complex of natural communities that occur in a repeated pattern on landscapes influences by the Great Lakes. The complex is a large-patch system comprised of linear arc-shaped communities that parallel the Great Lakes shoreline.

Issues/Problems

This model represents a complex of spatially explicit natural communities that occur in a repeatable pattern along the Great Lakes. Although some natural processes such as hydrology, plant succession, and wind action influence the entire complex, each community is also controlled by processes such as insects, disease, and possibly fire. These internal dynamics may set a community back to an earlier seral stage of specific community but not send it to a different class of the VDDT model. For example a drought or fire may kill a percentage of pine or oak trees on an inland dune ridge, setting the dry forest to a mid-seral stage, but given the topography of the complex it would not convert the dry dune ridge into a swale.

Additionally in the time-span of the LANDFIRE model (1000yrs) it is not possible to model the long-

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term processes that created these complexes, the gradual long-term decline in glacial lake water levels and post-glacial uplift. Also the fluctuation of glacial lake levels and post-glacial uplift were stochastic climatic events, making it difficult to guess when or if they may occur again.

Essentially, the VDDT classes as modeled represent two parallel pathways - one for dune and one for swale - on a time scale beyond the 1000yr time frame of the model. Therefore each class is set to range in age between 0-999yrs.

Comments

The large majority of the text in this model comes directly from MNFI abstract for Wooded Dune and Swale by Dennis Albert. See reference section for complete citation.

Vegetation Classes

Class A 23 %

Early Development 1 Open

Upper Layer Lifeform

- [x] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model

Description

Indicator Species* and Canopy Position

AMBR	Lower
CALO	Lower
POBA2	Upper
SALIX	Middle

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	60 %
Height	Herb 0m	Herb >1.1m
Tree Size Class	None	

- [x] Upper layer lifeform differs from dominant lifeform.

The dominant lifeform would be the herbaceous layer of Calamovilfa longifolia and Ammophila brevilgulata which could range in cover from 0-70%. Given that these are foredunes subject to shifting sands and blowouts large porions may un- to sparsely vegetated.

Early seral dune: On the landscape, this class would be located closest to the lake but since the VDDT model is aspatial, it is characterized here by its vegetation rather than its spatial location. This class may also be referred to a an open dune/foredune. It is influenced by along-shore currents, waves, wind and fluctuating Great Lakes water levels. Depending on the height of the dune, an increase in Great Lakes water levels, modeled as "optional 1" with the probability of occurring every 500yrs, could convert this class to class B (early seral swale). Also, a major storm event, modeled as wind/weather/stress with a 100yr probability could cause a dune blowout, causing class A to transition to class B.

Foredunes are typically 1-2m high and dominated by beach grass (Ammophila breviligulata), dune grass (Calamovilfa longifolia), Autumn willow (Salix serissima), dune willow (Salix cordata) and balsam poplar (Populus balsamifera). Rare plants such as Lake Huron tansy (Tanacetum huronense) and Pitcher's thistle (Cirsium pitcheri).

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100-year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement seve

Class B 22 %

Early Development 2 Open

Upper Layer Lifeform

- [x] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model

Indicator Species* and Canopy Position

JUNCU	Lower
ELAC	Lower
SCAM6	Lower
CLMA	Lower

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	61 %	90 %
Height	Herb 0m	Herb >1.1m
Tree Size Class	None	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Early seral swale (0-999yrs): On the landscape, this class would be located between the foredune and nearshore dunes closest to the lake but since the VDDT model is aspatial, it is characterized here by its vegetation rather than its spatial location. This class may also be referred to a an interdunal wetland, shore fen or herbaceous wetland. This zone would be influenced by short-term fluctuations in Great Lakes water levels. A decrease in Great Lakes water levels, modeled as "optional 2" with the probability of occurring every 500yrs, this class could convert to class A (early seral dune). Also a major storm event, modeled as "wind/weather/stress" with the probability of occurring every 100yrs could shift dune sands, converting the class to class A. This class succeeds to class E.

Common species include rushes (Juncus balticus, J. pelocarpus, J. nodosus), spike rush (Eleocharis acicularis), threesquare (Scripus americanus), twig-rush (Cladium mariscoides), sweet gale (myrica gale), shrubby cinquefoil (Potentilla fruticosa), blue-joint grass (Calamagrostis canadensis) and Kalm's lobelia (Lobelia kalmii).

Class C 28 %

Late Development 1 Closed

Upper Layer Lifeform

- [ ] Herbaceous
- [ ] Shrub
- [x] Tree

Fuel Model

Indicator Species* and Canopy Position

PIBA2	Upper
JUCO6	Low-Mid
PTAQ	Lower
PIRE	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	61 %	90 %
Height	Tree 10.1m	Tree 50m
Tree Size Class	Very Large >33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Trees in this class may be shorter than 10m but this limit was chosen to make class C mutually exclusive from class D.

Description

Low dune field and mid/late seral forested dune (200-999yrs): On the landscape this class would be located inland of the first series of dunes and swales. This class is characterized by more advanced plant succession. A replacement fire, modeled with the probability of occurring every 1000yrs, could convert this forested system to an open dune (class A). A mixed fire, modeled with the probability of occurring every 150yrs would maintain the system in this class.

In the low dune field common species include: Jack pine (Pinus banksiana), white pine (P. strobus) and red pine (P. resinosa) often forming a scattered overstory canopy, while ground juniper (Juniperus communis), creeping juniper (J. Horizontalis), bearberry (Arctostaphylos uva-ursi), beach grass, and June grass (Koeleria macrantha) form a scattered ground layer. The mid/late seral forested dunes with soils of medium to course sand, tend to be dominated by species common to dry-mesic and mesic northern forest (MNFI 1990). Soil

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*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100-year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement seve

moisture conditions appear to change dramatically with slight elevational changes and are reflected in the development of soil organic material and changing plant species. On higher, drier ridges, soils often have less than three cm of organic material. Red pine, white pine and red oak (Quercus rubra) are often co-dominant, while paper birch (Betula papyrifera), bigtooth aspen (Populus grandidentata), balsam fir (Abies balsamea), and red maple are sub-dominant or understory species. Bracken fern (Pteridium aquilinum), black huckleberry (Gaylussacia baccata), blueberry (Vaccinium myrtilloides), bunchberry (Cornus canadensis) and wintergreen (Gaultheria procumbens) occur in the shrub and ground layers.

Class D **27 %**

Late Development 2 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

THOC2	Upper
ACRU	Lower
ALINR	Upper
CAREX	Mid-Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	61 %	90 %
Height	Tree 0m	Tree 10m
Tree Size Class	Large 21-33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Trees in this class may be taller than 10m but this limit was chosen to make class D mutually exclusive from class C. Also some swales may be dominated by shrubs instead of trees.

Mid/late seral swale: (0-999): This class may range from shrub dominated to forested swales.

This class ranges in age from 201-999yrs, A major hydrologic change, such as increased precipitation leading to higher ground water levels or flooding may kill trees and shrubs, converting this class to an open wetland swale (class B). This was modeled using "wind/weather/stress" with the probability of occurring every 1000yrs.

Forested systems occur in dry or moist swales and are dominated by northern white cedar (Thuja occidentalis), speckled alder (Alnus rugosa), willows (Salix spp.), and red maple (Acer rubrum) In swales with standing water present through most of the year, sedges (Carex aquatilis) and (C. stricta), twigrush, marsh marigold (Caltha palustris), swamp candles (Lysimachia terrestris) and swamp cinquefoil (Potentilla palustris) commonly dominate the ground layer.

Class E **0 %**

[Not Used] [Not Used]

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☐ Tree

Fuel Model

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	%	%
Height		
Tree Size Class		

☐ Upper layer lifeform differs from dominant lifeform.

Description

Disturbances

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100-year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement seve

Fire Regime Group:** V

Historical Fire Size (acres)

Avg 0
Min 0
Max 0

Sources of Fire Regime Data

- [ ] Literature
- [ ] Local Data
- [ ] Expert Estimate

Fire Intervals	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	3333			0.00030	11
Mixed	434.8			0.0023	88
Surface					
All Fires	384			0.00261	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fir combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inver of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- [ ] Insects/Disease
- [ ] Native Grazing
- [x] Other (optional 1) short-term increase in Great Lakes water levels
- [x] Wind/Weather/Stress
- [ ] Competition
- [x] Other (optional 2) short-term decrease in Great Lakes water levels

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*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100-year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement seve

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*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100-year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement seve

LANDFIRE Biophysical Setting Model

***Biophysical Setting* 5014710** **Central Interior and Appalachian Floodplain Systems**

☐ *This BPS is lumped with:*
☐ *This BPS is split into multiple models:*

General Information

Contributors (also see the Comments field **Date** 4/11/2007

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Modeler 3			**Reviewer**		

Vegetation Type
Forest and Woodland

Map Zone
50

Model Zone
☐ Alaska ☐ N-Cent.Rockies
☐ California ☐ Pacific Northwest
☐ Great Basin ☐ South Central
☑ Great Lakes ☐ Southeast
☐ Northeast ☐ S. Appalachians
☐ Northern Plains ☐ Southwest

Dominant Species*

ACSA2	ACNEI2
SANI	FRPE
CELTI	PODE3
ULAM	PLOC

General Model Sources
☐ Literature
☐ Local Data
☑ Expert Estimate

Geographic Range
This system is found along medium and large river floodplains throughout the glaciated Midwest ranging from eastern KS and western MO to western OH and north along the Red River basin in MN. This system is found in all sections 222 in MN, WI, and MI and in section 251 in MN.

Biophysical Site Description
River valleys are linear depressions that contain a river channel and its floodplain, often embedded within a series of higher terraces. River valleys, formed by the meltwater of glaciers, occur in glacial outwash channels. The river floodplain is the low-lying area adjacent to the river that was formed under the present drainage system and is subject to periodic flooding and cycles of erosion and deposition. In contrast, terraces are former floodplain surfaces at higher elevations than the floodplain that were abandoned when the river channel incised lower into the valley floor. Within the broader landscape, river valleys represent an unusually diverse mosaic of landforms, physical environmental factors, species, and biological communities because of their abrupt environmental gradients and complex ecological processes (Brinson 1990, Gregory et al. 1991, Naiman et al. 1993). Floodplain forests occur along streams or rivers that are third order or greater (Strahler 1952).

Vegetation Description
The variety of soil properties associated with this system can create a mixture of vegetation. Acer saccharinum occurs on the wetter soils of floodplains in the eastern portion of this system, with Populus deltoides and willows, especially Salix nigra, occurring more in the western range of this system. Fraxinus pennsylvanica, Ulmus americana and Quercus macrocarpa occur in more well-drained areas.

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Understory species can vary across the range of this system but can include shrubs such as Cornus drummondii and Asimina triloba, and sedge and grass species. Oxbows within this system may have species such as Nelumbo lutea and Typha latifolia.

Disturbance Description

Floodplain systems are produced and maintained by active hydrologic and geomorphic processes such as channel meandering, sedimentation and erosion (Gregory, et al. 1991, Hughes 1994) caused by natural hydrological variation (Richter and Richter 2000). Regeneration of the early successional dominant species (cottonwood maple and willow) is dependent on flooding and movement of river channels, which creates bare, moist soil needed for seedling establishment (Noble 1979, Johnson et al. 1976, Scott et al. 1997). Oxbow and slough development also influence the floodplain system and create variability in plant community composition. Deposits of sand and other sediments can create low ridges that influence vegetation establishment (Weaver 1960). The flood frequency in a given area is dependent upon its location on the floodplain, with upper terraces having infrequent flooding and scouring events, while the lower terraces nearest the river flood frequently. Scouring caused by ice jams during the winter, channel meandering, and oxbow and slough development greatly influence this system.

Adjacency or Identification Concerns

Today, bank stabilization, dams and water diversion have significantly altered these floodplains.

Pollution and heavy metals may be an issue in this BpS due modern waste water issues and the flooding nature of this system.

Native Uncharacteristic Conditions

Scale Description

Patches must be adequate in size to contain natural variation in vegetation and disturbance regime. This system is often widespread on medium or larger rivers and should be at least 0.5 miles long and 100m wide.

Issues/Problems

Assumptions: This system is most affected by flooding, scouring and channel movement. We modeled the floodplain valley including forested and non-forested areas. The model does include wetlands, sloughs or oxbows. We used two flooding regimes in the model: Option 1 – minor flooding/scouring (2-20yr frequency); and Option 2 – major flooding/scouring (20-100yr frequency). Flood frequency for a class is based on location on the floodplain, with higher terraces being subject to longer flood cycles (up to 100yrs). We modeled attributes such as channel migration, oxbow and slough development and sedimentation. Fire activity had a minor impact, due to low intensity, infrequent intervals, small size and low fuel loads.

Comments

This model adapted from Rapid Assessment model R6FPFOgl Great Lakes Floodplain Forest by Robert Mayer (rmayer@fs.fed.us) and Rick Miller (rick.miller@dnr.state.oh.us) on 09/30/2005. Material from the MNFI community abstract for Floodplains (Tepley et al 2004) is also incorporated.

Vegetation Classes

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100-year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement seve

Class A 15 %

Early Development 1 All Structure

Indicator Species* and Canopy Position

PODE3	Upper
SALIX	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	71 %	100 %
Height	Shrub 1.1m	Shrub >3.1m
Tree Size Class	Sapling >4.5ft; <5"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Upper Layer Lifeform

- ☐ Herbaceous
- ☑ Shrub
- ☐ Tree

Fuel Model

Description

Early successional stage created by scouring and deposition following seasonal flooding and stream meander changes (Optional 1 in model). A mix of pioneer tree seedlings, shrubs (often willows) and herbaceous; primary succession. Rare surface fires.

This class ranges is age from 0-9yrs. This class succeeds to class B. Minor flooding/scouring, modeled as optional 1 with the probability of occurring every five years, would take the system to time zero. Surface fire, modeled with the probability of occurring every 100yrs would maintain the system in this class.

Class B 24 %

Mid Development 1 Open

Indicator Species* and Canopy Position

SALIX	Mid-Upper
PLOC	Upper
PODE3	Upper
	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	21 %	60 %
Height	Tree 5.1m	Tree 10m
Tree Size Class	Sapling >4.5ft; <5"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Description

This stage develops as the stand starts to mature. Low diversity stands. Dominant species are cottonwood, willow (sandbar, peach-leaved, black) and sycamore.

This class ranges is age from 10-30yrs. This class succeeds to class C. Minor flooding/scouring, modeled as optional 1 with the probability of occurring every four years, would maintain the system in this class. Mixed fire, modeled with the probability of occurring every 100yrs would also maintain the system in this class. Major flooding, modeled as optional 2 with the probability of occurring every 50yrs, would take the system back to class A.

Class C 44 %

Mid Development 1 Closed

Indicator Species* and Canopy Position

PLOC	Upper
PODE3	Upper
ACNE2	Upper
ACSA2	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	61 %	100 %
Height	Tree 5.1m	Tree 25m
Tree Size Class	Medium 9-21"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Description

Mixed canopy. Overstory is dominated by a mix of cottonwood, American elm, silver maple, box elder, red maple and sycamore. Vines and poison ivy are abundant in the understory.

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100-year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement seve

This class ranges is age from 30-150yrs. This class succeeds to class D. Minor flooding/scouring, modeled as optional 1 with the probability of occurring every four years, would maintain the system in this class. Major flooding, modeled as optional 2 with the probability of occurring every 50yrs, would take the system back to class B. Surface fire, modeled with the probability of occurring every 45yrs would also maintain the system in this class.

Class D **17 %**

Late Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

ACSA2	Upper
JUNI	Upper
FRPE	Upper
QUPA2	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	61 %	100 %
Height	Tree 25.1m	Tree 50m
Tree Size Class	Large 21-33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Found along upper terraces or areas protected from frequent flooding. Species diversity increases towards the south and east within the region. Overstory species include hackberry, American elm, ash (green and black), sycamore, black walnut, shagbark hickory, oak (bur, swamp, white), basswood, tulip poplar and maple (red and silver). Understory cover is often higher than in other classes in this model. Shrubs and small trees such as Lindera benzoin, Carpinus caroliniana, Cercis canadensis, Cornus spp. and Prunus virginiana are typical.

This class ranges in age >150yrs. Major flooding, modeled as optional 2 with the probability of occurring every 200yrs, would take the system back to class B. Surface fire, modeled with the probability of occurring every 50yrs, would maintain the class in D.

Class E **0 %**

[Not Used] [Not Used]

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☐ Tree

Fuel Model

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	%	%
Height		
Tree Size Class		

☐ Upper layer lifeform differs from dominant lifeform.

Description

Disturbances

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Fire Regime Group:** V

Historical Fire Size (acres)

Avg 3
Min 1
Max 35

Sources of Fire Regime Data

- ☐ Literature
- ☐ Local Data
- ☑ Expert Estimate

Fire Intervals	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement					
Mixed	396.5			0.00252	63
Surface	680.0			0.00147	37
All Fires	250			0.00400	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fir combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inver of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- ☐ Insects/Disease
- ☐ Wind/Weather/Stress
- ☐ Native Grazing
- ☐ Competition
- ☑ Other (optional 1) Minor Flooding 5-20yrs.
- ☑ Other (optional 2) Minor Flooding 20-500 yr.

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100-year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement seve

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100-year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement seve

LANDFIRE Biophysical Setting Model

Biophysical Setting 5014750 Laurentian-Acadian Floodplain Systems

☐ *This BPS is lumped with:*
☐ *This BPS is split into multiple models:*

General Information

Contributors (also see the Comments field **Date** 4/11/2007

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Modeler 3			**Reviewer**		

Vegetation Type
Forest and Woodland

Map Zone
50

Model Zone
☐ Alaska ☐ N-Cent.Rockies
☐ California ☐ Pacific Northwest
☐ Great Basin ☐ South Central
☑ Great Lakes ☐ Southeast
☐ Northeast ☐ S. Appalachians
☐ Northern Plains ☐ Southwest

Dominant Species*
ACSA2 ACNEI2
FRPE FRNI
CEOC
ULAM

General Model Sources
☐ Literature
☐ Local Data
☑ Expert Estimate

Geographic Range
This system is found from central MN through northern WI and northern MI east to New England. This system is limited to all sections 212 in MN, WI and MI.

Biophysical Site Description
River valleys are linear depressions that contain a river channel and its floodplain, often embedded within a series of higher terraces. River valleys, formed by the meltwater of glaciers, occur in glacial outwash channels. The river floodplain is the low-lying area adjacent to the river that was formed under the present drainage system and is subject to periodic flooding and cycles of erosion and deposition. In contrast, terraces are former floodplain surfaces at higher elevations than the floodplain that were abandoned when the river channel incised lower into the valley floor. Within the broader landscape, river valleys represent an unusually diverse mosaic of landforms, physical environmental factors, species, and biological communities because of their abrupt environmental gradients and complex ecological processes (Naiman et al. 1993, Gregory et al. 1991, Brinson 1990). Floodplain forests occur along streams or rivers that are third order or greater (Strahler 1952).

Vegetation Description
This complex includes floodplain forests, with Acer saccharinum characteristic, as well as herbaceous sloughs and shrub wetlands. Most areas are underwater each spring; microtopography determines how long the various habitats are inundated. Associated trees include Acer rubrum and Carpinus caroliniana, the latter frequent but never abundant. On terraces or in more calcareous areas, Acer saccharum or Quercus rubra may be locally prominent, with Betula alleghaniensis and Fraxinus spp. Salix nigra is characteristic of the levees adjacent to the channel. Common shrubs include Cornus amomum and Viburnum spp. The herb layer in the forested portions often features abundant spring ephemerals, giving

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way to a fern-dominated understory in many areas by mid-summer. Non-forested wetlands associated with these systems include shrub-dominated and graminoid-herbaceous vegetation.

Disturbance Description

Floodplain systems are produced and maintained by active hydrologic and geomorphic processes such as channel meandering, sedimentation and erosion (Gregory, et al. 1991, Hughes 1994) caused by natural hydrological variation (Richter and Richter 2000). Regeneration of the dominant species (silver maple and willow) is dependent on flooding and movement of river channels, which creates bare, moist soil needed for seedling establishment (Scott et al. 1997). Oxbow and slough development also influence the floodplain system and create variability in plant community composition. Deposits of sand and other sediments can create low ridges that influence vegetation establishment (Weaver 1960). The flood frequency in a given area is dependent upon its location on the floodplain, with upper terraces having infrequent flooding and scouring events, while the lower terraces nearest the river flood frequently. Scouring caused by ice jams during the winter, channel meandering, and oxbow and slough development greatly influence this system.

Adjacency or Identification Concerns

Today, bank stabilization, dams and water diversion have significantly altered these floodplains.

Native Uncharacteristic Conditions

Scale Description

Patches must be adequate in size to contain natural variation in vegetation and disturbance regime. This system is often widespread on medium or larger rivers and should be at least 0.5 miles long and 100m wide.

Issues/Problems

Assumptions: This system is most affected by flooding, scouring and channel movement. We modeled the floodplain valley including forested and non-forested areas. The model does include wetlands, sloughs or oxbows. We used two flooding regimes in the model: Option 1 – minor flooding/scouring (2-20yr frequency); and Option 2 – major flooding/scouring (20-100yr frequency). Flood frequency for a class is based on location on the floodplain, with higher terraces being subject to longer flood cycles (up to 100yrs). We modeled attributes such as channel migration, oxbow and slough development, and sedimentation. Fire activity had a minor impact, due to low intensity, infrequent intervals, small size and low fuel loads.

Comments

This model adapted from Rapid Assessment model R6FPFOgl Great Lakes Floodplain Forest by Robert Mayer (rmayer@fs.fed.us) and Rick Miller (rick.miller@dnr.state.oh.us) on 09/30/2005. Material from the MNFI community abstract for Floodplains (Tepley et al 2004) is also incorporated.

Vegetation Classes

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100-year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement seve

Class A 15 %

Early Development 1 All Structure

Indicator Species* and Canopy Position

ALIN2	Upper
SALIX	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	71 %	100 %
Height	Shrub 1.1m	Shrub 30.0m
Tree Size Class	Sapling >4.5ft; <5"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Upper Layer Lifeform

- ☐ Herbaceous
- ☑ Shrub
- ☐ Tree

Fuel Model

Description

Early successional stage created by scouring and deposition following seasonal flooding and stream meander changes (Optional 1 in model). A mix of pioneer shrubs (usually alders and willows), and herbaceous species. Rare surface fires.

This class ranges is age from 0-9yrs. This class succeeds to class B. Minor flooding/scouring, modeled as optional 1 with the probability of occurring every five years, would take the system to time zero. Surface fire, modeled with the probability of occurring every 100yrs would maintain the system in this class.

Class B 24 %

Mid Development 1 Open

Indicator Species* and Canopy Position

ACSA2	Upper
FRPE	Upper
FRNI	Upper
SALIX	Mid-Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	21 %	60 %
Height	Tree 5.1m	Tree 10m
Tree Size Class	Sapling >4.5ft; <5"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Description

This stage develops as the stand starts to mature. Low diversity stands. Dominant species are willow (sandbar and peach-leaved), green ash, black ash and silver maple.

This class ranges is age from 10-30yrs. This class succeeds to class C. Minor flooding/scouring, modeled as optional 1 with the probability of occurring every four years, would maintain the system in this class. Mixed fire, modeled with the probability of occurring every 100yrs would also maintain the system in this class. Major flooding, modeled as optional 2 with the probability of occurring every 50yrs, would take the system back to class A.

Class C 44 %

Mid Development 1 Closed

Indicator Species* and Canopy Position

ACSA2	Upper
ACRU	Upper
FRPE	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	61 %	100 %
Height	Tree 5.1m	Tree 25m
Tree Size Class	Medium 9-21"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Description

Mixed canopy composition. Overstory is dominated by a mix of American elm, silver maple, box elder, red maple, green ash, and sometimes conifers such as hemlock, white cedar and white pine.

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This class ranges is age from 30-150yrs. This class succeeds to class D. Minor flooding/scouring, modeled as optional 1 with the probability of occurring every four years, would maintain the system in this class. Major flooding, modeled as optional 2 with the probability of occurring every 50yrs, would take the system back to class B. Surface fire, modeled with the probability of occurring every 45yrs would also maintain the system in this class.

Class D 17 %

Late Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

ACSA2	Upper
TIAM	Upper
QURU	Upper
CEOC	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	61 %	100 %
Height	Tree 25.1m	Tree 50m
Tree Size Class	Large 21-33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Found along upper terraces or areas protected from frequent flooding. Species diversity increases towards the south and east within the region. Overstory species include basswood, white pine, red oak, hackberry, hemlock and sugar maple. Understory cover is often higher than in other classes in this model.

This class ranges in age >150yrs. Major flooding, modeled as optional 2 with the probability of occurring every 200yrs, would take the system back to class B. Surface fire, modeled with the probability of occurring every 50yrs, would maintain the class in D.

Class E 0 %

[Not Used] [Not Used]

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☐ Tree

Fuel Model

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	%	%
Height		
Tree Size Class		

☐ Upper layer lifeform differs from dominant lifeform.

Description

Disturbances

Fire Regime Group: III**

Historical Fire Size (acres)

Avg 3
Min 1
Max 35

Sources of Fire Regime Data

- ☐ Literature
- ☐ Local Data
- ☑ Expert Estimate

Fire Intervals	*Avg FI*	*Min FI*	*Max FI*	*Probability*	*Percent of All Fires*
Replacement					
Mixed	400			0.0025	15
Surface	67.96			0.01472	85
All Fires	58			0.01723	

Fire Intervals (FI):
Fire interval is expressed in years for each fire severity class and for all types of fir combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inver of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100-year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement seve

Additional Disturbances Modeled

☐ Insects/Disease	☐ Native Grazing	☑ Other (optional 1)	Minor Flooding 5-20yrs.
☐ Wind/Weather/Stress	☐ Competition	☑ Other (optional 2)	Minor Flooding 20-500 yr.

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LANDFIRE Biophysical Setting Model

Biophysical Setting 5014770 Boreal Acid Peatland Systems

☑ *This BPS is lumped with: 1479, 1481, 1477*
☐ *This BPS is split into multiple models:*

General Information

Contributors (also see the Comments field **Date** 4/10/2007

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Modeler 3	Randy Swaty	rswaty@tnc.org	**Reviewer**		

Vegetation Type
Wetlands/Riparian

Map Zone
50

Model Zone
☐ Alaska ☐ N-Cent.Rockies
☐ California ☐ Pacific Northwest
☐ Great Basin ☐ South Central
☑ Great Lakes ☐ Southeast
☐ Northeast ☐ S. Appalachians
☐ Northern Plains ☐ Southwest

Dominant Species*

PIMA	CHCA2
LALA	CALA11
LEGR	CAOL3
BEPU4	SPAF70

General Model Sources
☑ Literature
☐ Local Data
☑ Expert Estimate

Geographic Range

This system occurs in MI's Upper Peninsula, northern lower MI, MN and WI. It can also be found in scattered location in southern MI and the central sand plains and Lower Lake Michigan coastal areas of WI. It also occurs in NY and New England in small bogs. Occurs in 212 (all), 222 (R all), 222 (Kb,Kc,Ke), 222 (J all) and 222 (Ud, Ua).

Biophysical Site Description

Peatlands develop in humid climates where precipitation exceeds evapotranspiration (Gignac et al. 2000, Halsey and Vitt 2000, Boelter and Verry 1977). The northern Lake States are characterized by a humid, continental climate with long cold winters and short summers that are moist and cool to warm (Mitsch and Gosselink 2000, Damman 1990, Boelter and Verry 1977, Gates 1942). Two landscape features are conducive to the development of peat; small ice-block basins and poorly-drained, level terrain (Boelter and Verry 1977). Peatlands occurring on former glacial lake beds 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 (Lindeman 1941). Peatlands range in size from a few thousand square meters to several thousand hectares (Futyma and Miller 1986). The overall topography of peatlands is flat to gently undulating with microtopography characterized by hummocks and hollows (NatureServe 2006, Locky et al. 2005, Bubier 1991, Glaser et al. 1981, Wheeler et al. 1983, Vitt and Slack 1975, Heinselman 1963). The pronounced microtopography in these systems leads to extreme and fine-scale gradients in soil moisture and pH (Bridgham et al. 1996). Climate, topography, near surface geology, soils and vegetation influence the hydrology of peatlands (Miller and Futyma 1987). The accumulation of peat within these systems alters drainage patterns and raises water tables (Brinson 1993).

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Vegetation Description

Wet meadow/shrub carr are open wetlands dominated by dense cover of broad-leaved graminoids or tall shrubs. Present on mineral to sapric peat soils in basins or along streams. Moss cover is often less than five percent, but can range to >75%. Brown mosses are usually dominant, but sphagnum can be dominant on some sites. Characteristic species include Calamagrostis canadensis, Carex lacustris, Carex stricta, Lysimachia thyrsiflora, Spiraea alba, Alnus incana, American elm and black ash (MDNR 2003).

Poor fens are characterized by a graminoid-dominated herbaceous layer of low to moderate diversity (Bedford and Godwin 2003, Glaser et al. 1990, Verry 1975, Vitt and Slack 1975, Curtis 1959, Gates 1942). Minerotrophic species such as Betula pumila, Carex lasiocarpa, Menyanthes trifoliate, Potentilla palustris and Salix pedicellaris help distinguish poor fens from bogs (MDNR 2003).

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 (NatureServe 2006, Glaser et al. 1981, Verry 1975, Vitt and Slack 1975, Curtis 1959, Gates 1942). The harsh growing conditions of poor conifer swamps (high acidity, low nutrient availability, and saturated peat) results in a unique but depauperate flora; relatively few species have evolved the necessary adaptations to survive ombrotrophic conditions (Mitsch and Gosselink 2000, Glaser 1992, Siegel 1988). Poor conifer swamps are characterized by an exceptionally distinct plant community with similarity throughout its range (Curtis 1959). Although species diversity is low, minerotrophic indicators are typical. Sphagnum species form nearly continuous carpets consisting of low hummocks and extensive lawns; other characteristic species include Smilacina trifolia, Sarracenia purpurea, Carex trisperma, Eriophorum vaginatum, Ledum groenlandicum, Chamaedaphne calyculata, Alnus incana, black spruce and tamarack (MDNR 2003).

Muskegs are characterized by low ericaceous, evergreen shrubs, a poor herbaceous layer dominated by sedges and a hummocky carpet of sphagnum moss, and widely scattered or clumped, stunted conifers (NatureServe 2006, Glaser et al. 1991, Verry 1975, Vitt and Slack 1975, Curtis 1959, Gates 1942). Floristically muskegs are homogenous and of limited plant diversity, exhibiting remarkably uniform structure and composition across their wide range (Riley 1989, Curtis 1959). Minerotrophic indicator species are absent or present only as single individuals or single clones. A carpet of Sphagnum is usually present, although Pleurozium schreberi is often very abundant and forms large mats covering drier mounds in shaded sites. Other characteristic species include Carex trisperma, Eriophorum vaginatum, Ledum groendlandicum and black spruce (MDNR 2003).

Open bogs are characterized by a continuous carpet of sphagnum moss, a poor herbaceous layer, low ericaceous, evergreen shrubs, and widely scattered and stunted conifer trees (NatureServe 2005a, Glaser et al. 1991, Verry 1975, Vitt and Slack 1975, Curtis 1959, Gates 1942). Floristically open bogs are homogenous and of limited diversity, exhibiting remarkably uniform structure and composition across their wide range (Riley 1989, Curtis 1959). The harsh growing conditions of bogs (high acidity, low nutrient availability, and saturated peat) results in a unique but depauperate flora: relatively few species have evolved the necessary adaptations to cope with ombrotrophic conditions (Mitsch and Gosselink 2000, Glaser 1992, Siegel 1988). Characteristic species include Carex oligosperma, Eriophorum vaginatum, Sarracenia purpurea, Chamaedaphne calyculata, Kalmia polifolia, Vaccinium oxycoccos, Andromeda glaucophylla and Ledum groenlandicum.

Disturbance Description

Succession within peatland systems is not unidirectional but stochastic, with rates and pathways of succession determined by a complex array of interacting biotic and abiotic factors (Klinger 1996,

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Jasieniuk and Johnson 1982). Bogs can succeed to poor conifer swamp or remain as bogs depending on the site's hydrology (lowered water tables will allow for the establishment of trees), disturbance regime (fire and flooding will keep open systems open), and species composition (a seed source of conifer trees in the vicinity is required and some ericaceous species can limit seedling establishment and tree growth). Where poor conifer swamp is invading an open bog, the youngest trees are found closest to the bog while the oldest trees are farthest from the bog (Klinger 1996).

Once established, poor conifer swamp can persist for hundreds of years given stable hydraulic conditions and the absence of fire. Poor conifer swamps and muskegs can be even-aged or uneven-aged depending on the disturbance history and age of a site. Younger stands, regenerated following fire tend to be even-aged with tall dense canopies, while older stands tend to be uneven-aged with more open canopies and variable heights (Groot 2002, Harper et al. 2002, Groot and Horton 1994, Morin and Gagnon 1991, Taylor et al. 1988 ,Barnes and Wagner 1981, Curtis 1959). Within even-aged stands, stratification of species into distinct size classes is common. This structural feature occurs because one species (e.g., black spruce) obtains a disproportionate share of the finite resources at the expense of the other species (e.g., tamarack or balsam fir) (Newton and Smith 1988). Within dense, stands of even-aged black spruce, density dependent mortality or self-thinning typically occurs after several decades (Carleton and Wannamaker 1987). As poor conifer swamps and muskegs age, they tend to become more complex structurally but with relatively stable tree species composition. The structural diversity of old-growth poor conifer swamps (200-300yrs old) provides important habitat for regional biodiversity. Small scale disturbance factors, such as windthrow events and insect herbivory (e.g., spruce budworm), generate numerous snags, coarse woody debris, and gaps within the canopy. These canopy gaps are captured primarily by black spruce layering but also by swamp conifer seedlings. Compared to trees established from seed, layers tend to be of shorter stature. As stands age, they become more open with discontinuous canopies. In addition to structural complexity, epiphytic diversity tends to increase with stand age since older trees are available for a longer period of time for epiphytic colonization, vegetative expansion, and sexual reproduction (Harper et al. 2005, Ruel et al. 2004, Harper et al. 2003, Harper et al. 2002, Groot 2002, Groot and Horton 1994, Bergeron and Dubuc 1989). Old-growth, uneven-aged poor conifer swamps are most prevalent in fire resistant landscapes and in extensive areas of peatland forest, which have reduced fire frequencies (Groot 2002).

Fire, which is an infrequent but important disturbance factor within poor conifer swamps and muskegs, controls tree population dynamics by initiating and terminating succession (Cleland et al. 2004, Miller and Futyma 1987, Futyma and Miller 1986, Whitney 1986, Foster 1985, Payette and Gagnon 1979, Curtis 1959). The primary ignition source for fires within poor conifer swamps and muskegs is summer lightning strike (Foster 1985, Rowe 1973), however, historically fires started by Native Americans in surrounding uplands (Chapman 1984, Day 1953), likely spread to some swamp forests. 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 swamps in fire-protected landscapes (Cleland et al. 2004, Whitney 1986). Fire rotation period typically increases from south to north and with increasing organic soil moisture (Sirois and Payette 1989). The accumulation of thick organic soils often prolongs the fire cycle within these systems (Foster 1985). In addition, forest floor thickness, which increases with time since fire, is negatively correlated with fire severity (Fenton et al. 2005, Ruel et al. 2004). Fire frequency can also be reduced by fire breaks such as bodies of water and deciduous forests (Rowe 1973).

Fire severity and frequency in poor conifer swamps and muskegs is 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 enough to burn (Schwintzer and Williams 1974, Vogl 1964). When the surface peat burns,

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the fire releases organic matter from the peat, stimulates decay, slows peat accumulation, and exposes mineral soil (Jean and Bouchard 1991, Damman 1990, Rowe 1973, Vogl 1964). Fires within poor conifer swamps and muskegs are typically stand-replacing crown fires that kill the majority of canopy trees (Harper et al. 2002, Knowles 1991a, Bergeron and Dubuc 1989, Curtis 1959). Depending on its severity, fire can eliminate or reduce the soil organic layer (Fenton et al. 2005, Harper et al. 2005, Ruel et al. 2004). Fires in poor conifer swamps and muskegs generate a flush of growth, first in ground layer taxa and ericaceous shrubs, and then in coniferous trees. Increased growth, seed and fruit production and flowering results from increases in light availability, soil temperature, decomposition rates and nutrient availability (Ruel et al. 2004, Larsen and MacDonald 1998, Foster 1985, Barnes and Wagner 1981, Rowe 1973).

Exposure of the mineral soil provides a suitable medium for the establishment and germination of swamp conifers (i.e., black spruce, tamarack, jack pine and northern white cedar) (Brown et al. 1988, Barnes and Wagner 1981, Curtis 1959). Species present in abundance before the fire are typically at an advantage for extending their distributions afterward (Rowe 1973). Cone serotiny provides black spruce and jack pine a competitive advantage in terms of seeding onto burned sites in that fire-killed trees can provide seed. Tamarack, white pine, cedar, and balsam fir must rely on wind or animal dispersal from seed trees that survived the fire or occur in neighboring, unburned stands (Knowles 1991a). The majority of seedlings typically establish within the first couple of years following the fire (Rajora and Pluhar 2003, St-Piere and Gagnon 1992, Morin and Gagnon 1991) but recruitment at a lessened rate often continues for several decades following the disturbance and initial pulse of seedlings (Larsen and MacDonald 1998, Groot and Horton 1994, Sirois and Payette 1989). The initially established trees often serve as an internal seed source. The rate of reforestation following fire is dependent on the size and severity of the burn; centers of large burns are especially slow to restock (Foster 1985). Swamps in which the organic layer burns evenly tend to support rapid seedling establishment and become even-aged (Foster 1985); these stands can even be monospecific (typically dominated by black spruce or tamarack) if the diversity of seed source is limited (Bergeron and Dubuc 1989). Seed source availability and seedbed availability and quality determine the burned stand's tree density as well as composition (Sirois and Payette 1989). Fires of weak severity leave much of the organic layer intact, which can result in slow and irregular recruitment because of the limited availability of mineral soil seedbed (Fenton et al. 2005, Harper et al. 2005, Foster 1985) and may facilitate the conversion of poor conifer swamp to muskeg (Vogl 1964). In fire prone landscapes, periodic fire can also maintain open peatlands: conversely, fire suppression in these areas can lead to the conversion of open bogs to poor conifer swamps (Vitt and Slack 1975, Curtis 1959).

Fires typically cause change in species abundance but not in species composition. In contrast, water regime and nutrient regime changes result in drastic modification of species composition and abundance (Jasieniuk and Johnson 1982). Beaver, through their dam-building activities, can instigate substantial hydrologic change to peatland systems, either causing flooding or the lowering of the water table of poor conifer swamps and muskegs depending on the location of the forest in relation to the dam (Futyma and Miller 1986, Jeglum 1975, Heinselman 1963, Curtis 1959, Gates 1942). Behind a beaver dam the water table is higher while below it, drier conditions are generated (Jeglum 1975). 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 (Islam and MacDonald 2004, Islam et al. 2003). Prolonged flooding of poor conifer swamps and muskegs can result in the death of canopy trees and the conversion of forested peatlands to bogs or even open systems dominated by marsh and fen vegetation (Asada et al. 2005). Flooding can also cause grounded peat mats to become loosened from the bottom and float (Asada et al. 2005, Gates 1942). Flooding induced tree mortality is greater on grounded peat mats compared to free floating mats: free mats float up with a rising water table while grounded mats become inundated and have shallower aerobic zones (Asada et al. 2005,

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Schwintzer 1979, Schwintzer 1978a, Schwintzer 1973). Roots of peatland trees are physiologically active near the surface and are quickly killed when the water table rises following flooding (Glaser and Janssens 1986). Flooding typically causes tree mortality after about a decade but different tree species have different tolerances for flooding (Asada et al. 2005, Janssen 1967). Tamarack, which is often most prevalent on wet sites, exhibits greater flooding tolerance than black spruce. In response to prolonged soil flooding, tamarack produces adventitious roots which increase root hydraulic conductivity or the capacity to regulate water flow (Islam and MacDonald 2004, Islam et al. 2003). However, tamarack can also be more deleteriously affected by flooding than black spruce since it is often restricted to hollows while black spruce is elevated on hummocks (Denyer and Riley 1964).

The lowering of the water table through beaver damming or climatic changes can also dramatically effect the species composition and successional trajectory of poor conifer swamps and muskegs. Lowering of a forested peatland's water table results in increased soil aeration, soil temperature, decomposition, nutrient availability and consequently tree growth (Pepin et al. 2002, MacDonald and Yin 1999, Liefers and MacDonald 1990, Liefers and Rothwell 1987, Liefers and Rothwell 1986, Jasieniuk and Johnson 1982). Increased tree growth following lowering of the water table is especially prevalent in species such as tamarack, which often establishes in wet microsites (i.e., hollows). Species such as black spruce, which are often more prevalent on hummocks, may be detrimentally impacted by lengthy periods of drying because of water stress. 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 (MacDonald and Yin 1999). In addition, a low water table for a prolonged period of time can cause the decomposition of the organic layer (Curtis 1959) and the conversion of poor conifer swamp to a more minerotrophic forest type. Lowering of the water table in open peatland systems can lead to the conversion to shrub swamp or poor conifer swamp (Gignac et al. 2000).

The natural disturbance regime in poor conifer swamps and muskegs is also influenced by wind. Trees growing in poor conifer swamp are particularly susceptible to windthrow because saturated sphagnum peat provides a poor substrate for anchoring trees (Harper et al. 2002, Burns 1906). As noted above, the living roots of woody peatland plants occur in a shallow rooting zone, generally restricted to the uppermost 15 cm where there is sufficient oxygen to maintain aerobic respiration (Hamel et al. 2004). The poor drainage of poor conifer swamps and muskegs and the superficial rooting of swamp trees results in numerous windthrows (Harper et al. 2003, Harper et al. 2002, Barnes and Wagner 1981, Curtis 1959, Dansereau and Segadas-Vianna 1952). Most windthrow only partially disturbs a stand, creating small canopy gaps but complete canopy destruction can also occur (Harper et al. 2002, Groot and Horton 1994). Catastrophic, stand-leveling blowdowns are infrequent disturbance factors in poor conifer swamps and muskegs, with return intervals likely >1000yrs. As noted above, small-scale wind disturbance, along with insect herbivory, contribute to the structural diversity of poor conifer swamps and muskegs. Small-scale wind disturbance, along with insect herbivory contribute to the structural diversity of muskegs by generating moderate pit and mound topography, standing snags, and woody debris, which is quickly enveloped by the sphagnum.

Poor conifer swamps, which often contain dense monospecific stands, are inherently susceptible to epizootic attacks of insects and parasites. The plant parasite Arceuthobium pusillum (dwarf mistletoe) can increase the mortality of black spruce (Barnes and Wagner 1981, Gates 1942, Coburn et al. 1933). Two insect defoliators are most prevalent in peatlands, Pristiphora erichsonii (larch sawfly) and Choristoneura fumiferana (spruce budworm) (Newton and Jolliffe 1998, Barnes and Wagner 1981, Curtis 1959). Spruce budworm defoliates both black spruce and balsam fir but tends to be more detrimental to the later. The principal effect of spruce budworm outbreaks on black spruce stands is the increase in competitive

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asymmetry with smaller conspecifics suffering from greater competition-induced mortality post-defoliation (Newton and Jolliffe 1998). Tamarack growing in poor conifer swamps often suffers from repeated defoliation by larch sawfly (Girardin et al. 2005, Tilton 1977). The life of a given tamarack is typically characterized by a series of defoliation episodes, most of which are short in duration and of moderate intensity (Graham 1956). However, prolonged larch sawfly attacks can lead to extensive mortality of tamarack. Larch sawfly outbreaks tend to be more severe on better drained sites; hydric sites have defoliation episodes of lower intensity and duration due to the severe restrictions on sawfly development and survival imposed by a high water table (Girardin et al. 2005).
Although a more recent arrival in MI, the larch casebearer is beginning to cause heavy defoliation to tamarack, especially in the eastern and central Upper Peninsula.

Native ericaceous shrubs can profoundly limit the establishment and growth of swamp conifer trees through competitive inhibition and also through the production of allelopathic compounds. Many of the ericaceous plants that thrive in poor conifer swamps are fire-adapted and often resprout vigorously and grow densely following fire or clear cuts (Wheeler et al. 1983). Rapid and prolific resurgence of ericads, which resprout or sucker from underground organs, can directly limit tree seedling establishment and growth (Yamasaki et al. 1998, Zhu and Mallik 1994, Foster 1985). Sheep-laurel has been found to produce allelopathic compounds that inhibit the growth and development of black spruce. These water soluble and heat stable substances hinder the primary root development of black spruce and are also believed to negatively impact the ecotomycorrhizal fungi associated with black spruce (Yamasaki et al. 1998, Zhu and Mallik 1994, Thompson and Mallik 1989, Peterson 1965). The negative effects of sheep-laurel on black spruce root growth are most pronounced under acidic conditions (Zhu and Mallik 1994).

Poor fens and bogs can succeed to poor conifer swamp or northern shrub thicket. Lowering of the water table of fens and bogs 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 (Gignac et al. 2000, Almendinger and Leete 1998, Riley 1989, Schwintzer 1981, Miller 1981, Schwintzer and Williams 1974). Conversions of bog to fen can also occur, however with far less frequency (Glaser et al. 1990). A discharge of alkaline groundwater at the peat surface of a bog, caused by a change in hydraulic head, can result in the conversion of bog vegetation to fen vegetation (Glaser et al. 1990, Siegel and Glaser 1987). Mixing of as little as 10% groundwater from underlying calcareous parent material with acid bog water is sufficient to raise the peatland pH from 3.6 to 6.8 (Glaser et al. 1990). Fens and bogs are very sensitive to changes in pH and subsequent availability of nutrients: fen vegetation can replace bog flora when pH increases above 4.5 (Siegel 1988).

Disturbance factors influencing poor fens and bogs include fire, flooding, windthrow and insects. Numerous fens contain charcoal within their peat profile (Heinselman 1963, Curtis 1959) and many researchers have reported fire as a prevalent part of fen's disturbance regime (Vitt and Slack 1975, Curtis 1959, Gates 1942). Surface fire can contribute to the maintenance of fens and bogs by killing encroaching trees and shrubs without completely removing the peat, which is normally saturated (Vitt and Slack 1975, Curtis 1959). Graminoid dominance of fen systems can be perpetuated by surface fires (Bowles et al. 1996). In addition, many of the ericaceous plants that thrive in fens and bogs are fire adapted and often grow densely following fire (Wheeler et al. 1983). Fire severity and frequency in fens and bogs is closely related to fluctuations in water level. Prolonged periods of lowered water table can allow the surface peat to dry out enough to burn (Schwintzer and Williams 1974). When the surface peat of fens and bogs burns, the fire releases organic matter from the peat, kills seeds and latent buds, stimulates decay and slows peat accumulation (Jean and Bouchard 1991, Damman 1990). 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

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succession to more minerotrophic peatlands such as poor fen or intermittent wetland.

As noted above, flooding can result in the conversion of fens to bogs. Flooding can also contribute to fen maintenance. Roots of peatland trees are physiologically active near the surface and are quickly killed when the water table rises following flooding (Glaser and Janssens 1986). Option 1 is a permanent to semi-permanent increase in water levels. Option 2 is a permanent to semi-permanent decrease in water levels.

Adjacency or Identification Concerns

Native Uncharacteristic Conditions

Scale Description

This BpS can range from hundreds of acres to less than five acres in size. The larger delineations typically occur in central to northern MN, the eastern Upper Peninsula of MI and the smaller and scattered delineations in the western Upper Peninsula, northern Lower Peninsula and northern WI. These areas have a relatively low alpha diversity, but can vary considerably in beta diversity even within the same delineation. They may also contain scattered, better-drained islands with mineral soils and hardwoods in the larger delineations.

Issues/Problems

Comments

A significant portion of the text is a result of Michigan Natural Features Inventory (MNFI) abstracts developed by MNFI staff and the Field Guide to the Native Plant Communities of Minnesota: the Laurentian Mixed Forest Province by the Minnesota Department of Natural Resources.

Vegetation Classes

Class A 14 %

Early Development 1 All Structure

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

SPIRA	Low-Mid
ALNUS	Middle
CALAM	Lower
CALA16	Lower

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	30 %
Height	Tree 0m	Tree 5m
Tree Size Class	None	

☑ Upper layer lifeform differs from dominant lifeform.

The herb/moss lifeform may be dominant. Canopy closure is 0%. Min height is 0m, max height is 1.1m. The shrub lifeform may also be dominant. Canopy closure min is 50%, max 100%. Min height is 0.6m, max height is 3.1m.

Description

Wet meadow/shrub carr are open wetlands dominated by dense cover of broad-leaved graminoids or tall shrubs. Present on mineral to sapric peat soils in basins or along streams. Moss cover is often less than five percent, but can range to >75%. Brown mosses are usually dominant, but sphagnum can be dominant on some sites. Characteristic species include Calamagrostis canadensis, Carex lacustris, Carex stricta, Lysimachia thyrsiflora, Spiraea alba, Alnus incana, American elm and black ash. Sphagnum covers can quickly invade the wet meadow/shrub carr when water levels stabilize. The chemistry of these sites can be quickly converted by sphagnum to poor fen conditions before characteristic wet meadow species have been

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replaced by plants of poor fens. The process of succession of wet meadow/shrub carr to poor fen can be reversed by return of higher or more variable water level.

Class B **17 %**

Mid Development 1 Open

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Description

Indicator Species* and Canopy Position

SPHAG2	Lower
CALA11	Lower
CAOL3	Upper
BEPU4	Low-Mid

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	30 %
Height	Tree 5.1m	Tree 10m
Tree Size Class	None	

☑ Upper layer lifeform differs from dominant lifeform.

The herb/moss lifeform or the shrub lifeform are the dominant lifeform. Moss cover is nearly always 100%. Herbs are abundant, with graminoids often being the dominant vegetation. Low shrubs are the dominant speces on many sites and can have >50% cover.

Poor fens are open sphagnum peatlands with variable development of hummocks and hollows. Dominated either by fined-leaved sedges or low shrubs. Present in small basins, on floating mats near lakes and ponds, and in large peatlands on glacial lake plains. Species diversity is low, but minerotrophic species such as Betula pumila, Carex lasiocarpa, Menyanthes trifoliate, Potentilla palustris and Salix pedicellaris help distinguish poor fens from bogs. Poor fens occur in peatlands where the peat surface is nearly isolated from mineral-rich runoff and is becoming increasingly acidic (pH is 4.2-5.5). Poor fens can develop through the acidification of wet meadows. This can occur in basins and on floating mats where invasion and accumulation of Sphagnum elevates the surface peat, isolating plant roots from underlying minerotrophic water.

Class C **37 %**

Late Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Description

Indicator Species* and Canopy Position

LARIX	Mid-Upper
PIMA	Mid-Upper
CHAMA	Low-Mid
SPHAG2	Lower

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	31 %	50 %
Height	Tree 5.1m	Tree 25m
Tree Size Class	None	

☐ Upper layer lifeform differs from dominant lifeform.

Poor conifer swamps are conifer-dominated peatlands with sparse canopy of stunted trees. Understory is depauperate and dominated by ericaceous shrubs, fine-leaved graminoids, and low hummocks of sphagnum moss. Tree canopy cover is usually 25-50%. Surface water pH is usually >4.1. Species diversity is low, but minerotrophic indicators are typical. Sphagnum species form nearly continuous carpets consisting of low hummocks and extensive lawns; other characteristic species include Smilacina trifolia, Sarracenia purpurea, Carex trisperma, Eriophorum vaginatum, Ledum groenlandicum, Chamaedaphne calyculata, Alnus incana, black spruce and tamarack. In general, poor conifer swamps develop in peatlands where the peat surface is becoming isolated from mineral-rich groundwater because of buildup of peat and invasion by sphagnum. They may also develop from poor fens where the formation of sphagnum hummocks creates sufficiently aerated condition for the establishment and growth of black spruce and tamarack. Catastrophic fires in poor

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conifer swamps are not common. An analysis of the Public Land Survey (PLS) records in MN indicates that the historic rotation for catastrophic fires was about 570yrs. Moderate surface fires and light windthrow were somewhat more common disturbances in poor conifer swamps, occurring about every 90yrs. There is little direct evidence that windthrow has a significant impact on poor conifer swamps. The PLS records in MN suggest the historic rotation of catastrophic windthrow was about 500yrs.

Class D **23 %**

Late Development 2 All Structures

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

PIMA	Upper
LEGR	Low-Mid
CATR10	Lower
SPHAG2	Lower

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	51 %	70 %
Height	Tree 5.1m	Tree 25m
Tree Size Class	None	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Muskegs are black spruce dominated peatlands on deep peat. Canopy is often sparse (25-75% cover), with stunted trees. Understory is dominated by ericaceous shrubs and fine-leaved graminoids on high Sphagnum hummocks. Minerotrophic indicator species are absent or present only as single individuals or single clones. A carpet of sphagnum is usually present, although Pleurozium schreberi is often very abundant and forms large mats covering drier mounds in shaded sites. Other characteristic species include Carex trisperma, Eriophorum vaginatum, Ledum groendlandicum and black spruce. Muskegs occur where buildup of peat causes the peat surface to become isolated from mineral-rich runoff or subsurface flow so that all mineral inputs come from precipitation. Although fires can occur in muskegs, they are not very common. An analysis of the Public Land Survey (PLS) records in MN indicates that the historic rotation of catastrophic fires was in excess of 1000yrs. These fires can result in conversion of a muskeg to an open bog community; if sufficient nutrients are released into surface waters by burning of peat and vegetation, the bog may be converted to a poor fen. Surface fires appear to have been more common, occurring about every 120yrs. There is little direct evidence that windthrow has a significant impact on muskegs. The PLS records in MN suggest the historic rotation of catastrophic windthrow was about 700yrs.

Class E **9 %**

Late Development 3 Open

Upper Layer Lifeform

- ☑ Herbaceous
- ☐ Shrub
- ☐ Tree

Fuel Model

Indicator Species* and Canopy Position

SPHAG2	Lower

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	20 %
Height	Herb 0m	Herb 0.5m
Tree Size Class		

☑ Upper layer lifeform differs from dominant lifeform.

Dominant lifeform is the herb/moss lifeform.

Description

Open bogs are sphagnum-dominated peatlands with microtoppgraphy ranging from deep hollows and low sphagnum carpets to well-developed high hummocks. Present in large patterned peatlands and in small basins in nutrient-poor outwash plains and in areas of non-calcareous till deposits in scoured bedrock terrain. Surface water pH is <4.2 and Minerotrophic indicator species are absent. Sphagnum cover is about 90%, other mosses 10%; other characteristic species include Carex oligosperma, Eriophorum vaginatum, Sarracenia purpurea, Chamaedaphne calyculata, Kalmia polifolia, Vaccinium oxycoccos, Andromeda glaucophylla and Ledum groenlandicum. Open bogs develop where the peat surface becomes elevated, isolating it from mineral-rich runoff or groundwater. The saturated conditions and rapid accumulation of

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Sphagnum peat prevent or inhibit establishment and growth of black spruce and tamarack. Open bog can originate from transformation of muskeg after a wind or fire event that eliminated tree canopy. Loss of the tree canopy results in reduced evapotranspiration and increasingly water-logged conditions, causing a shift toward greater presence of carpet forming Sphagnum species and the development of wet hollows. Ericaceous shrubs and other xerophytic bog species are the predominant vegetation on the remaining hummocks.

Disturbances

Fire Regime Group:** III

Historical Fire Size (acres)

Avg
Min
Max

Sources of Fire Regime Data

- [x] Literature
- [ ] Local Data
- [x] Expert Estimate

Fire Intervals	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	714.3	1	1000	0.0014	15
Mixed					
Surface	125	1	1000	0.008	85
All Fires	106			0.00941	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fir combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inver of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- [x] Insects/Disease
- [x] Wind/Weather/Stress
- [ ] Native Grazing
- [ ] Competition
- [x] Other (optional 1) Flooding
- [ ] Other (optional 2)

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LANDFIRE Biophysical Setting Model

***Biophysical Setting* 5014790** **Central Interior and Appalachian Swamp Systems**

☐ *This BPS is lumped with:*
☐ *This BPS is split into multiple models:*

General Information

Contributors (also see the Comments field **Date** 4/10/2007

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Modeler 3			**Reviewer**		

Vegetation Type
Forest and Woodland

Map Zone
50

Model Zone
☐ Alaska ☐ N-Cent.Rockies
☐ California ☐ Pacific Northwest
☐ Great Basin ☐ South Central
☑ Great Lakes ☐ Southeast
☐ Northeast ☐ S. Appalachians
☐ Northern Plains ☐ Southwest

Dominant Species*

ACSA2	QUPA2
ACRU	PLOC
FRPE	QUBI
FRNI	ULAM

General Model Sources
☐ Literature
☐ Local Data
☑ Expert Estimate

Geographic Range
These wetlands are scattered throughout the north-central midwest (south of the Laurentian region) the north-central Appalachians and southern New England at low to mid elevations. In MZ51 the system is found in subsection 251Dh, and throughout all subsections of 222J and 222U. In MZ50 the system in found throughout 222ke, Kf and Kg.

Biophysical Site Description
Central Interior and Appalachian Swamp Systems can be found in several landscapes. Some swamp systems are found in surface-water depressions where the vegetation is separated from the water-table and the hydrology is driven by surface water. This type of system is found commonly over clay where there would be a perched water table. These sites experience significant seasonal hydrologic fluctuation, with the water table typically above the soil surface in spring and significantly below the surface during summer. Forested wetlands primarily impacted by surface water are common over broad areas of glacial lakeplain. Also swamp systems are found in ground-water depressions where groundwater is influencing the hydrology of the system. This type of system would be found over a coarse-textured soil substrate. These sites experience less hydrologic fluctuation than the surface-water depressional sites, and typically occupy relatively small areas relative to surface water influenced sites (Mitsch and Gosselink 2000).

Vegetation Description
This system is comprised of a variety of lowland hardwoods, including silver maple (Acer saccharinum), red maple (Acer rubrum), green ash (Fraxinus pennsylvanica), black ash (Fraxinus nigra), American elm (Ulmus americana), pin oak (Quercus palustris), swamp white oak (Quercus bicolor), sycamore (Platanus occidentalis), cottonwood (Populus deltoides) and a variety of other canopy associates. Silver maple,

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green ash, sycamore and cottonwood favor sites that experience seasonal inundation, whereas black ash favors organic deposits that are not subject to extreme hydrologic fluctuations. Stands are generally closed-canopy. Shrub and groundlayer diversity depends on canopy closure and hydrology, but is generally low on seasonally inundated sites. Hummocks, canopy openings and decomposing wood support higher diversity. Stands referred to as "flatwoods" range from wet to mesic, with species composition changing accordingly. Flatwoods on relatively dry substrate may be dominated by sugar maple (Acer saccharum), oaks and occasionally beech (Fagus grandifolia).

Typical ground layer species may occur Onoclea sensibilis (sensitive fern), Osmunda cinnamomea (cinnamon fern), Osmunda regalis (royal fern), Symplocarpus foetidus (skunk cabbage) Toxiodendron radicans (poison ivy), Parthenocissus quinquefolia (Virginia creeper), Caltha palustris (marsh-marigold), Glyceria striata (manna grass) and Lycopus spp. (water-horehound).

Disturbance Description

The dominant disturbance in this BpS is seasonal water table fluctuation, leading to varying periods of inundation. Spring flooding restricts seed germination and diversity of shrubs and ground layer species. Summer drought is an additional stressor. Shallowly rooted trees are subject to windthrow, but are typically rooted in mineral soils, which have greater structural stability than organic soils.

Adjacency or Identification Concerns

This system commonly occurs as small to large patches in a matrix of fire-resistant systems, including beech-maple forest, and sometimes associated with fire-adapted systems, including oak savanna. This system is often referred to as ash, red maple or maple-ash-oak swamp (the latter particularly in OH). The majority of pre-European settlement acreage has been drained and converted to agriculture. Structure of remaining sites may be simplified by anthropogenic disturbances, including hydrologic alteration, grazing, and introduction of invasive species. Invasive species occurring in this system include glossy buckthorn (Rhamnus frangula), garlic mustard (Alliaria petiolata), Japanese barberry (Berberis thunbergii) and multiflora rose (Rosa multiflora). Also the introduction of Dutch elm disease into North American forests has largely elimated large elms from native ecosystems.

Native Uncharacteristic Conditions

Strong dominance by red maple may indicate previous disturbance (grazing or pasturing, hydrologic alteration, beaver flooding, etc.).

Scale Description

This system typically occurs as small to large patches, the largest patches occurring on glacial clay and sand-clay lakeplain.

Issues/Problems

Comments

Vegetation Classes

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100-year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement seve

Class A 24 %

Early Development 1 All Structure

Upper Layer Lifeform

- ☐ Herbaceous
- ☑ Shrub
- ☐ Tree

Fuel Model

I

Indicator Species* and Canopy Position

CEOC2	Low-Mid
CORU	Low-Mid
ILVE	Low-Mid
COAM2	Low-Mid

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	100 %
Height	Shrub 0m	Shrub 30.0m
Tree Size Class	None	

☐ Upper layer lifeform differs from dominant lifeform.

Description

This stage ranges from 0-29yrs and succeeds to class B. This stage is an early successional stand following flooding or a rare stand-replacing fire. Shrubs increase in dominance over time, although open grass- and sedge-dominated wet meadow may be dominant for the first 10yrs+, particularly in areas in which existing shrubs were flood-killed. Open to dense thicket dominated by species such as Ilex verticillata (winterberry), Vaccinium corymbosum (highbush blueberry), Lindera benzoin (spicebush), Viburnum spp., Alnus rugosa (speckled alder) Cephalanthus occidentalis (buttonbush), Corylus cornuta (hazelnut), Salix spp.(willows) and Cornus spp. (dogwoods).

This stage results from major disturbance, including stand-replacement fire, flooding, or windthrow. Rare replacement fires, modeled with the probability of occurring every 1000yrs, and catastrophic windthrow can maintain the system in class A (an early shrub-herb- dominated successional stage). Flooding caused by beaver or other natural hydrologic alteration is estimated to occur every 300yrs, although this number may be much higher, and will also maintain the system in class A. Shrub thickets are sometimes relatively stable and long-persistent, but the concept used for this model is of a site that, due to edaphic factors, favors the development of forested wetland in the absence of major disturbance(s). As with all stages of this system, seasonal annual spring flooding, would occur. This natural process was not explicitly modeled but it should be assummed that it is occurring annually and maintaining the swamp forest instead of allowing it to succeed to drier forest type.

Class B 35 %

Mid Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

ACRU	Upper
ACSA2	Upper
FRPE	Upper
FRNI	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	100 %
Height	Tree 0m	Tree 10m
Tree Size Class	Large 21-33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Mid-development forested swamp stage: 30-79yrs old. Scattered tree canopy develops from seedlings that establish under shrubs. Typical species include silver maple (Acer saccharinum), red maple (Acer rubrum), green ash (Fraxinus pennsylvanica), black ash (Fraxinus nigra), American elm (Ulmus americana), pin oak (Quercus palustris), swamp white oak (Quercus bicolor), sycamore (Platanus occidentalis), cottonwood (Populus deltoides) and a variety of other canopy associates. General appearance is of a shrub-dominated system with an open tree canopy, grading into forested wetland at the end of this period.

As with all stages of this system, seasonal annual spring flooding, would occur. This natural process was not explicitly modeled but it should be assummed that it is occurring annually and maintaining the swamp forest instead of allowing it to succeed to drier forest type.

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This stage transitions to class C in the absence of major disturbance(s). Replacement fires were estimated to occur every 1000yrs; this likely varied across the region and depending on the nature of the upland matrix in any given area (fire-dependent vs. fire-intolerant). Replacement fires return the system to class A (an early shrub- (herb-) dominated successional stage. Flooding caused by beaver or other natural hydrologic alteration is estimated to occur every 300yrs, although this number may be much higher, and will return the system to class A.

Class C **41 %**

Late Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

ACRU	Upper
ASCA2	Upper
FRPE	Upper
FRNI	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	100 %
Height	Tree 10.1m	Tree 50m
Tree Size Class	Very Large >33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Mature forested swamp: Mature, multi-seral stands aged 80+ This stage is dominated by the same tree species as class B although the shrub layer is greatly reduced.

This stage is maintained by frequent windthrow of single trees or small to large patches of trees, modeled with the probability of occurring every 100yrs. Replacement fires were estimated to occur every 700-1000yrs; this likely varied across the region and depending on the nature of the upland matrix in any given area (fire-dependent vs. fire-intolerant). Replacement fires return the system to class A (an early shrub- (herb-) dominated successional stage. Catastrophic windthrow was estimated to occur every 600yrs and would also return the system to class A. Flooding caused by beaver or other natural hydrologic alteration is estimated to occur every 300yrs, although this number may be much higher, and will return the system to class A.

As with all stages of this system, seasonal annual spring flooding, would occur. This natural process was not explicitly modeled but it should be assumed that it is occurring annually and maintaining the swamp forest instead of allowing it to succeed to drier forest type.

Class D **0 %**

[Not Used] [Not Used]

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☐ Tree

Fuel Model

Description

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	%	%
Height		
Tree Size Class		

☐ Upper layer lifeform differs from dominant lifeform.

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Class E **0 %**

[Not Used] [Not Used]

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☐ Tree

Fuel Model

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	%	%
Height		
Tree Size Class		

☐ Upper layer lifeform differs from dominant lifeform.

Description

Disturbances

Fire Regime Group: V**

Historical Fire Size (acres)

Avg 0
Min 0
Max 0

Sources of Fire Regime Data

- ☐ Literature
- ☐ Local Data
- ☐ Expert Estimate

Fire Intervals

	Avg FI	*Min FI*	*Max FI*	*Probability*	*Percent of All Fires*
Replacement	1000			0.001	98
Mixed					
Surface					
All Fires	998			0.00102	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fir combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inver of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- ☐ Insects/Disease
- ☑ Wind/Weather/Stress
- ☐ Native Grazing
- ☐ Competition
- ☐ Other (optional 1)
- ☐ Other (optional 2)

References

Mitsch, W.J. and J.G. Gosselink, eds. 2000. Wetlands: Third Edition. John Wiley and Sons, New York.

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100-year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement seve

LANDFIRE Biophysical Setting Model

***Biophysical Setting* 5014810** **Laurentian-Acadian Alkaline Conifer-Hardwood Swamp**

☐ *This BPS is lumped with:*
☐ *This BPS is split into multiple models:*

General Information

Contributors (also see the Comments field **Date** 4/10/2007

Modeler 1	Brad Slaughter	slaughterb@michigan.gov	**Reviewer**	Chris Dunham	cdunham@tnc.org
Modeler 2			**Reviewer**	Dave Cleland	dcleland@fs.fed.us
Modeler 3			**Reviewer**	Tim Christiansen	tim.christiansen@us.army.mil

Vegetation Type

Forest and Woodland

Map Zone

50

Model Zone

☐ Alaska ☐ N-Cent.Rockies
☐ California ☐ Pacific Northwest
☐ Great Basin ☐ South Central
☑ Great Lakes ☐ Southeast
☐ Northeast ☐ S. Appalachians
☐ Northern Plains ☐ Southwest

Dominant Species*

THOC2	PIST
ABBA	FRNI
PIMA	ACRU
LALA	TSCA

General Model Sources

☑ Literature
☐ Local Data
☑ Expert Estimate

Geographic Range

This system occurs throughout the upper midwest and northeastern US and adjacent Canadian provinces, including MI, MN, WI, Ontario, Manitoba, Quebec, NY, NH, VT, ME, and northern IL, IN and OH (Faber-Langendoen 2001). This system also possibly occurs in PA, CT, NJ, RI, MA, New Brunswick and Nova Scotia. Within MZs 41, 50 and 51, this system occurs in section 222J (absent in 222Ji, and local in 222Jb, Jh, , Jg, and Je), local in 222Ud and Ue, 212H, 212R, 212S, 212J, 212X, 212T, 212Q, 222R, 212Z (local) 212K, 212N, 212M, 212L, 222K (local), 222L (local) and 222M (local).

Biophysical Site Description

This system is characterized by dense to open, low to medium-tall forests of needle-leaf evergreen and deciduous trees on shallow organic and deep peatland soils, occurring as discontinuous pockets or stringers within upland vegetation communities having both short-return-interval fire regimes (e.g., pine and oak-pine barrens) and long-return-interval fire regimes (e.g., northern hardwoods). In MN and the eastern UP they may occur in very extensive delineations occupying thousands of acres, and occur in patches several hundred to >1000ac in size in northern WI and northern lower MI. Low hummocks and water-filled depressions may be present, especially around the edges. These edges tend to be rich fen in the closed canopy peatland. Forested rich peatlands (pH > 5.5) occur in closed wet depressions, especially in small watersheds or catchment areas, and drains and toe slopes adjacent to streams. Soils are very poorly drained, saturated throughout the growing season in normal years, and may be deep organic peat (peatlands) or <12in of organic peat over primarily sandy soils. Vegetative composition and structure varies depending on landform, disturbance history and hydrology, including lateral flow of groundwater.

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The most typical dominant canopy species is northern white-cedar (see MN DNR 2003, Kost 2002, Christensen et al. 1959). Trees on poorly drained peats with restricted groundwater movement may be stunted.

Vegetation Description

Northern white-cedar (Thuja occidentalis) is the characteristic dominant canopy species in forested alkaline peatlands. It is commonly associated with balsam fir (Abies balsamea), black spruce (Picea mariana) and tamarack (Larix laricina). Occasional canopy species include white spruce (Picea alba), hemlock (Tsuga canadensis), white pine (Pinus strobus), black ash (Fraxinus nigra), red maple (Acer rubrum), yellow birch (Betula alleghaniensis), paper birch (B. papyrifera), American elm (Ulmus americana), quaking aspen (Populus tremuloides) and bigtooth aspen (P. grandidentata). Hemlock and white pine tend to occur on shallow peats or poorly drained mineral soils. Hardwoods also become more common on shallow peats and hydric mineral soils, or in frequently flooded zones (black ash and red maple, in particular, in flood-prone areas), and may dominate or co-dominate stands in the southern portion of BpS range. Tamarack is locally dominant, and may replace northern white-cedar where lateral flow of groundwater is minimal or absent. Shrubs are locally common, particularly in recent windfalls. Characteristic species include tag alder (Alnus rugosa), winterberry (Ilex verticillata), mountain holly (Nemopanthus mucronatus), red-osier dogwood (Cornus stolonifera), elderberry (Sambucus canadensis), huckleberry (Gaylussacia baccata), autumn willow (Salix serissima) and Canada yew (Taxus canadensis), the latter species having been significantly reduced by deer herbivory (Van Deelen et al. 1996). Low shrubs include Labrador tea (Ledum groenlandicum), blueberry (Vaccinium angustifolium), bilberry (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 currant (R. triste) and swamp black current (R. lacustre). The surface layer is dominated by mosses, primarily sphagnum. Brown mosses dominate pools. Pleurozium schreberi and Callicladium haldanianum may also be abundant. Liverworts are also abundant. The ground layer is diverse, particularly in sedges, ferns and orchids. Characteristic species include three-leaved Solomon's seal (Smilacina trifolia), twinflower (Linnaea borealis), small northern bog orchid (Platanthera obtusata), lesser rattlesnake plantain (Goodyera repens), yellow lady's slipper (Cypripedium parviflorum var. pubescens), showy lady's slipper (C. reginae), starflower (Trientalis borealis), goldthread (Coptis trifolia), naked miterwort (Mitella nuda), dwarf raspberry (Rubus pubescens), creeping snowberry (Gaultheria hispidula), one-flowered pyrola (Moneses uniflora), Carex leptalea, C. disperma, C. gynocrates, C. trisperma, C. interior, C. eburnea, C. vaginata, bulbet fern (Cystopteris bulbifera) and oak fern (Gymnocarpium dryopteris). Shrub and groundlayer density and structure is variable, depending on canopy closure, microtopography and hydrology. Vegetation data taken primarily from Kost (2002) and MN DNR (2003).

Disturbance Description

Fire Regime Group V characterizes this system. Conifer- and hardwood-conifer dominated lowland forests occur as isolated to extensive patches occurring in landscapes dominated by both fire-prone and fire-resistant upland matrix systems, and the fire regime is generally driven by the return interval of these upland vegetation types. Fires may occur following drought cycles and may be severe, but sites are typically very wet and fires are infrequent. Windthrow disturbances occur as a result of shallow rooting, affecting single trees and small to large patches of trees. Insect and disease outbreaks primarily affect mature or overmature dominant trees in both closed and open canopies, impacting black spruce, white spruce, tamarack and balsam fir in particular. Also, changes in hydrology, such as flooding or draining due to the construction or destruction of beaver dams, are another important disturbance in this system and typically change the entire unit into a wetland with an open succession pathway. Non-replacement mixed-severity fires can occur randomly in any class and are randomly associated with lightning strikes or

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small fires in the surrounding vegetation. Frequency will be about twice that of replacement-stand fires, which were estimated to occur in MN on a 920yr interval (MN DNR 2003). Catastrophic windthrow may have occurred on a 400-1000yrs+ rotation, with a median of 700yrs. Light windthrow (small patches) occurred on a rotation of 40-380yrs, with a median of 85yrs.

Adjacency or Identification Concerns

This concept includes "cedar swamps" and associated hardwood-conifer dominated lowland forests on alkaline substrates.

Native Uncharacteristic Conditions

Scale Description

This BpS can range from thousands of acres to less than five acres in size. The largest delineations typically occur in central and northern MN and the eastern Upper Peninsula of MI. Scattered large delineations also occur in northern WI, the western Upper Peninsula and northern Lower Peninsula of MI, and northern WI. Delineations in the southern portion of the Great Lakes region are generally small (<100ac) and widely distributed. These areas are generally homogeneous in vegetation composition, but can vary considerably in overstory coverage even within the same delineation. They may also contain scattered, better-drained islands with mineral soils and hardwoods in the larger delineations.

Issues/Problems

Separation of a cedar-dominated lowland/peatland was also discussed but it was decided to not attempt to separate at this scale. [BSS: acidic peatlands were eliminated from the coarse model. Current model focuses on cedar and hardwood-conifer dominated alkaline lowland forests.] Fire response was also determined to not be sufficiently different at this time. Present maps of this PNVG were also determined to be lacking in accuracy. There was consensus that a great deal more acres actually exist than are shown for MI and WI.

Comments

NOTE 5/20/08: As a result of final QC for LANDFIRE National by Jennifer Long the min height in class A was changed from “Tree 0m” to “Shrub 0.0m” and the max height changed from “Tree 5m” to “Shrub >3.1m” because according to LANDFIRE National rules height should only be designated for the upper-layer lifeform, listed as “Shrub” and the class description indicated that class A is “an early shrub- (herb-) dominated successional stage.”

BSS model based on an adaptation of from the Rapid Assessment Model R6COLLif Conifer Lowland embedded in Fire Resistant Ecosystem by Kelly Ann Gorman (KellyAnn_Gorman@nps.gov), Robert Wagner (rwanger@fs.fed.us) and Randy Swaty (rswaty@tnc.org) on 09/30/2005.

Comments from Rapid Assessment: Peer Review by Dave Cleland and Greg Nowacki, USFS Northeast Region 9 Forest Ecologists, at Milwaukee, WI: 21 July, 2004. Assumptions: Native American fire was considered but was not determined to be a significant factor. The disturbance called Optional 1 is a placeholder representing changes in hydrology; it did not receive a probability because it happens infrequently on the scale of individual bogs and because it would be an open pathway, sending stands out of the model rather than resetting succession to A.

Vegetation Classes

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Class A 14 %

Early Development 1 All Structure

Upper Layer Lifeform

- ☐ Herbaceous
- ☑ Shrub
- ☐ Tree

Fuel Model

Indicator Species* and Canopy Position

LALA	Upper
ALIN2	Mid-Upper
ILVE	Mid-Upper
VACO	Middle

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	20 %
Height	Shrub 0m	Shrub >3.1m
Tree Size Class	Sapling >4.5ft; <5"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

0-29yrs old. Early successional stand following flooding or stand-replacing fire (rare). Shrubs increase dominance over time, although open grass- and sedge-dominated wet meadow may be dominant for the first 10yrs+, particularly in areas in which existing shrubs were flood-killed. Open to dense thicket dominated by tag alder and winterberry, potentially associated with willows, nannyberry, and mountain holly. Early successional trees establish (particularly tamarack and black ash) in the absence of additional disturbance; northern white-cedar and/or white pine may establish from seed following catastrophic fire.

This stage results from major disturbance, including stand-replacement fire, flooding, or windthrow. Replacement fires were estimated to occur every ~920yrs in MN (MN DNR 2003); this likely varied across the region and depending on the nature of the upland matrix in any given area (fire-dependent vs. fire-intolerant). Replacement fires maintain the system in class A (an early shrub- (herb-) dominated successional stage). Catastrophic windthrow was estimated to occur every 600yrs in MN but would most occur in this early succesional stage. Flooding caused by beaver or other natural hydrologic alteration, modeled as wind/weather/stress is estimated to occur every 300yrs, although this number may be much higher, and will maintain the system in class A. Insect outbreaks were not modeled due to the fact that most of this system is dominated by northern white-cedar, which is not generally impacted by this disturbance type. Alder-dominated thickets are sometimes relatively stable and long-persistent, but the concept used for this model is of a site that, due to edaphic factors, favors the development of forested wetland in the absence of major disturbance(s).

In reality, a variety of early successional communities can result from major disturbance of conifer or conifer-hardwood dominated alkaline lowland forest. Class A is meant to capture a "typical" disturbance-followed-by-succession scenario.

Class B 11 %

Early Development 2 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

THOC2	Upper
PIMA	Upper
LALA	Upper
ACRU	Mid-Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	21 %	70 %
Height	Tree 5.1m	Tree 10m
Tree Size Class	Pole 5-9" DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Maximum height higher for the oldest trees.

Description

30-55 yrs old. Scattered tree canopy develops from hardwood and conifer seedlings that establish under shrubs. Typical species include black ash, tamarack, northern white-cedar, and balsam fir. General appearance is of a shrub-dominated system with an open tree canopy, grading into forested wetland at the end of this period.

This stage transitions to class C in the absence of major disturbance(s). Replacement fires were estimated to

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occur every ~920yrs in MN (MN DNR 2003); this likely varied across the region and depending on the nature of the upland matrix in any given area (fire-dependent vs. fire-intolerant). Replacement fires return the system to class A (an early shrub- (herb-) dominated successional stage. Catastrophic windthrow was estimated to occur every 600yrs in MN. This would also return the system to class A. Flooding caused by beaver or other natural hydrologic alteration is estimated to occur every 300yrs, although this number may be much higher, and will return the system to class A. Insect outbreaks were not modeled due to the fact that most of this system is dominated by northern white-cedar, which is not generally impacted by this disturbance type.

Class C **21 %**

Mid Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

THOC2	Upper
PIMA	Upper
LALA	Upper
ACRU	Mid-Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	71 %	100 %
Height	Tree 5.1m	Tree 25m
Tree Size Class	Pole 5-9" DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

56-115yrs old. Mid-aged stands dominated by cedar with some black spruce, balsam fir, and tamarack; may include red maple; some shrub layer; >70% canopy closure. Scattered successional species (e.g., quaking aspen, paper birch) present in the canopy, but declining as stands age.

This stage matures to class D in the absence of major disturbance(s). Replacement fires were estimated to occur every ~920yrs in MN (MN DNR 2003); this likely varied across the region and depending on the nature of the upland matrix in any given area (fire-dependent vs. fire-intolerant). Replacement fires return the system to class A (an early shrub- (herb-) dominated successional stage. Catastrophic windthrow, modeled as wind/weather/stress was estimated to occur every 600yrs in MN. This would also return the system to class A. Flooding caused by beaver or other natural hydrologic alteration, also modeled as wind/weather/stress, is estimated to occur every 300yrs, although this number may be much higher, and will return the system to class A. Insect outbreaks were not modeled due to the fact that most of this system is dominated by northern white-cedar, which is not generally impacted by this disturbance type.

Class D **54 %**

Late Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

THOC2	Upper
PIMA	Upper
FRNI	Upper
ABBA	Mid-Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	71 %	100 %
Height	Tree 25.1m	Tree 50m
Tree Size Class	Medium 9-21"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Canopy height typically ca. 20-25m; supercanopy white pines >25m may be present. On deep peats, average DBH of old-growth canopy cedars may be <21in. One documented old-growth stand in MI's eastern Upper Peninsula contains canopy trees of ca. 60-100cm DBH (up to 40in).

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Mature, multi-seral stands typically dominated by northern white-cedar, with black spruce and balsam fir usually important. Other canopy species may include tamarack (but this typically in open microsites and peripherally), white pine, hemlock, and a variety of hardwoods, the latter in low numbers except where favored due to hydrology (streambanks, frequently flooded areas) or substrate (thin organic or mineral soils). Canopy cover generally >75% but may be lower, particularly in areas associated with active groundwater discharge or peat deposition (these grade into open rich fen).

This stage is maintained by frequent windthrow of single trees or small to large patches of trees. Replacement fires were estimated to occur every ~920yrs in MN (MN DNR 2003); this likely varied across the region and depending on the nature of the upland matrix in any given area (fire-dependent vs. fire-intolerant). Replacement fires return the system to class A (an early shrub- (herb-) dominated successional stage. Catastrophic windthrow, modeled as wind/weather/stress was estimated to occur every 600yrs in MN. This would also return the system to class A. Flooding caused by beaver or other natural hydrologic alteration (also modeled as wind/weather/stress) is estimated to occur every 300yrs, although this number may be much higher, and will return the system to class A. Insect outbreaks were not modeled due to the fact that most of this system is dominated by northern white-cedar, which is not generally impacted by this disturbance type.

Class E **0 %**

[Not Used] [Not Used]

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☐ Tree

Fuel Model

Description

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	%	%
Height		
Tree Size Class		

☐ Upper layer lifeform differs from dominant lifeform.

Disturbances

Fire Regime Group:** V

Historical Fire Size (acres)

Avg
Min
Max

Sources of Fire Regime Data

- ☑ Literature
- ☐ Local Data
- ☑ Expert Estimate

Fire Intervals

	Avg FI	*Min FI*	*Max FI*	*Probability*	*Percent of All Fires*
Replacement	1000			0.001	98
Mixed					
Surface					
All Fires	998			0.00102	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inver of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- ☐ Insects/Disease
- ☑ Wind/Weather/Stress
- ☐ Native Grazing
- ☐ Competition
- ☐ Other (optional 1)
- ☐ Other (optional 2)

References

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LANDFIRE Biophysical Setting Model

Biophysical Setting 5014920 Great Lakes Coastal Marsh Systems

☐ *This BPS is lumped with:*
☐ *This BPS is split into multiple models:*

General Information

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Vegetation Type
Wetlands/Riparian

Map Zone
50

Model Zone
☐ Alaska ☐ N-Cent.Rockies
☐ California ☐ Pacific Northwest
☐ Great Basin ☐ South Central
☑ Great Lakes ☐ Southeast
☐ Northeast ☐ S. Appalachians
☐ Northern Plains ☐ Southwest

Dominant Species*

SCPU10	CACA4
SCAC3	CALA16
JUBA	ELRO2
TYLA	DAFL3

General Model Sources
☑ Literature
☑ Local Data
☑ Expert Estimate

Geographic Range
Great Lakes Coastal Marsh Systems are found along the margin of all the Great Lakes - Huron, Ontario, Michigan, Erie, Superior and rivers that connect to the Great Lakes. This model represents the Great Lakes marshes in MZ 41, 50 and 51. The system is found along the Great Lakes Coast Line in sections 222Ja; 212 Ha, Hb, Hf, Hj, Hl, and Hg; 212 Sq and Sb; 212 Ra, Rd, and Re; 222 Ue,Ud, and Ua. In WI and MN the system occurs in 222 kg, 212 2c, 212 Tf and Te, 212 Ya, 212 La and Lb, 212 Ma and Mb.

Biophysical Site Description
Great Lakes marshes are found along the shoreline the Great Lakes. Glacial landforms, in combination with recent longshore transport processes, create the prevalent physiographic features along much of the Great Lakes shoreline. Their characteristic differences in substrate, soils, slope and drainage conditions largely determine both natural shoreline configuration and sediment composition. These, in turn, generate distinctive contexts for wetland development that vary in their exposure and resilience to lake processes, and in their floristic composition.

Vegetation Description
Abiotic variables such as aquatic system, water level fluctuations, surficial bedrock, glacial landform, and climate combine to determine the species composition and floristic quality of Great Lakes coastal wetlands. In general Great Lakes marshes are dominated by graminoids such as Schoenoplectis acutus, Schoenoplectis pungens, Eleocharis palustris, Juncus balticus, Carex lacustris, and Eleocharis rostellata. In protected areas algal precipitation of calcium carbonate forms marly mats that supports calcium-loving plants.

Disturbance Description
Fluctuations in water levels are one of the most important influences on Great Lakes wetlands. These

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fluctuations occur over three temporal scales: (1) short-term fluctuations (seiche) in water level caused by persistent winds and/or differences in barometric pressure; (2) seasonal fluctuations reflecting the annual hydrologic cycle in the Great Lakes basin; and (3) interannual fluctuations in lake level as a result of variable precipitation and evaporation within their drainage basins (Minc 1997, Minc and Albert 1998). All of these scales contribute to the dynamic character of coastal wetlands, although interannual fluctuations result in the greatest wetland variability. These extreme lake-level fluctuations can range from 3.5-6.5ft (1.3-2.5m), and occur with no regular periodicity. In general, as water levels rise and fall, vegetation communities shift landward during high-water years and lakeward during low-water years. However, fluctuating lake levels effect not only a change in water depth, but a broad range of associated stresses to which plants must respond, including changes in water current, wave action, turbidity (clarity or light penetration), nutrient content or availability, alkalinity, and temperature, as well as ice scour and sediment displacement. Since
individual species display different tolerance limits along one or more of these dimensions, species composition can also change dramatically within a zone.
Coastal wetland systems are adapted to and require periodic inundation.

Adjacency or Identification Concerns

Water-level regulation has significantly reduced the occurrence of extreme high and low water levels on Lake Ontario and to a lesser degree on Lake Superior. This disruption of the natural cycle favors species intolerant of water-depth change, excludes species requiring periodic exposure of fertile substrates, and potentially leads to a reduction of species diversity. The dominance of cat-tails in many Lake Ontario marshes suggests a trend toward reduced species diversity following a reduction in the amplitude of natural water-level fluctuations (Wilcox et al. 1993).

Both urban and agricultural development have resulted in severe degradation and loss of coastal marshes through pollution, land management, and ecosystem alteration: Urban development has impacted coastal wetlands in the following ways:

 Armoring of the shoreline and dredging of channels to create harbors has resulted in marsh elimination.
 Dumping of waste materials such as sawdust and sewage, and a wide variety of chemicals has mechanically and chemically altered the shallow-water marsh environment, increasing turbidity, reducing oxygen concentrations, and altering the pH.
 Shipping traffic has mechanically eroded shoreline vegetation.

Water-level control of the Great Lakes and connecting rivers has altered natural wetland dynamics. Agriculture has had the following impacts on coastal wetlands:

 Drainage has eliminated large areas of marshes and coastal wetlands.
 Sedimentation has greatly increased turbidity, eliminating submergent species requiring clear water.
 Nutrient loading has locally reduced oxygen levels, prompted algal blooms, and led to the dominance of high-nutrient tolerant species such as cat-tails.
 Heavy agricultural sedimentation has led to the deposition of rich organic mud in the wet meadows and along the shoreline, favoring the dominance of early successional species.
 Introduction of exotic plants has altered macrophyte species composition.

Several exotic plants and animals pose a threat to the integrity of coastal wetlands. Exotics often outcompete native organisms, as well as altering their habitat (Hart et al. 2000). Significant exotic plants include Lythrum salicaria, Phragmites australis, Phalaris arundinacea, Myriophyllum spicatum (Eurasian

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milfoil), Potamogeton crispus (curly-leaf pondweed), and many less aggressive species. Hydrocharis morisranae, an aggressive floating-leaved plant, is expanding westward from the St. Lawrence River and Lake Ontario into Lake Erie and the Detroit River, and has recently been documented in Michigan.

Exotic animals include Dreissena polymorpha (zebra mussel), Cyprinus carpio (common carp), Neogobius spp. (gobies), and Bythotrephes cederstroemi (spiny water flea), to name but a few. Many exotics arrive in shipping ballast and many others were purposefully introduced.

Native Uncharacteristic Conditions

Scale Description

This system can be a linear system occurring along the Great Lakes or a small-medium patch system found at deltas.

Issues/Problems

This description and models cover a range of vegetation types including shore fens, marshes and estuaries. Height ranges added for class C by MHW at MiFSL based on NRCS because fields were left blank by modelers.

Comments

The text in the General Information section of this model was copied from the Michigan Natural Features Abstract for Great Lakes Marsh by Dennis Albert. See References section for complete citation.

Vegetation Classes

Class A 22 %

Early Development 1 All Structure

Upper Layer Lifeform

- [x] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model

Indicator Species* and Canopy Position

PORI2	Lower
HEDU2	Lower
VAAM3	Lower
POOB2	Lower

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	100 %
Height	Herb 0m	Herb 0.5m
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform.

Description

Submergent Marsh: Heteranthera dubia, Miriophylium exalbescens, Potamogeton obtusifolius, Potamogeton richardsonii and Vallisneria americana.

With a decrease in Great Lakes water levels, modeled using the "optional 1" at a probability of occurring every 40yrs (0.025) the submergent marsh phase would transition to class B. Without changes in Great Lakes water levels the system would stay in this class.

Class B 23 %

Early Development 2 All Structure

Upper Layer Lifeform

- [x] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model

Indicator Species* and Canopy Position

TYLA	Low-Mid
SCAC3	Lower
JUBA	Low-Mid
VAAM3	Lower

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	100 %
Height	Herb 0.6m	Herb >1.1m
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform.

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Description

Emergent Marsh: Chara globularis, Najas flexilis, Nymphaea odorata, Potamogeton odorata, Potamogeton graminieus, Scripus acutus and Vallisneria americana.

With a decrease in Great Lakes water levels, modeled using the "optional 1" at a probability of occurring every 40yrs (0.025) the emergent marsh phase would transition to class C. An increase in Great Lakes water levels, modeled using the "optional 2" at a probability of occurring every 40yrs (0.025) would send the emergent marsh to class A (submergent marsh). Without changes in Great Lakes water levels the system would stay in this class.

Class C **55 %**

Mid Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☑ Shrub
- ☐ Tree

Fuel Model

Indicator Species* and Canopy Position

CACA4	Lower
ALIN2	Middle
ELRO2	Low-Mid
CALA16	Lower

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	100 %
Height	Shrub 0m	Shrub 30.0m
Tree Size Class	None	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Shrub swamp/wet meadow/shore fen: Alnus rugosa, Calamagrostis canadensis, Carex lacustris, Carex stricta, Scutellaria galericulata, Typha latifolia, Potentialla fruticosa, Eleocharis rostellata.

A significant increase in Great Lakes water levels, modeled using the "optional 2" at a probability of occurring every 100yrs (0.01) would send the subemgent marsh (class B).

Class D **0 %**

[Not Used] [Not Used]

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☐ Tree

Fuel Model

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	%	%
Height		
Tree Size Class		

☐ Upper layer lifeform differs from dominant lifeform.

Description

Class E **0 %**

[Not Used] [Not Used]

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☐ Tree

Fuel Model

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	%	%
Height		
Tree Size Class		

☐ Upper layer lifeform differs from dominant lifeform.

Description

Disturbances

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Fire Regime Group:** NA

Historical Fire Size (acres)

Avg 0
Min 0
Max 0

Sources of Fire Regime Data

- ☐ Literature
- ☐ Local Data
- ☐ Expert Estimate

Fire Intervals	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement					
Mixed					
Surface					
All Fires					

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inver of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

☐ Insects/Disease	☐ Native Grazing	☑ Other (optional 1)	Decline in Great Lakes water levels
☐ Wind/Weather/Stress	☐ Competition	☑ Other (optional 2)	Increase in Great Lakes water levels

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LANDFIRE Biophysical Setting Model

***Biophysical Setting* 5014930** **Central Interior and Appalachian Shrub-Herbaceous Wetland Systems**

☐ *This BPS is lumped with:*
☐ *This BPS is split into multiple models:*

General Information

Contributors (also see the Comments field **Date** 4/10/2007

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Modeler 3			**Reviewer**		

Vegetation Type
Wetlands/Riparian

Map Zone
50

Model Zone
☐ Alaska ☐ N-Cent.Rockies
☐ California ☐ Pacific Northwest
☐ Great Basin ☐ South Central
☑ Great Lakes ☐ Southeast
☐ Northeast ☐ S. Appalachians
☐ Northern Plains ☐ Southwest

Dominant Species*

CAST8	EUPE3
CAAQ	COFO
CACA4	COAM2
EUMA6	SALA2

General Model Sources
☑ Literature
☐ Local Data
☑ Expert Estimate

Geographic Range

These systems occur throughout the Great Lakes region and Midwest in Ontario, Canada, and IA, IL, IN, MI, MN, MO, ND, OH, SD and WI. In MZs 41, 50 and 51, it occurs in 222Ja, Jc, Jf, Ud, Ue, Ua, Jg, Je, Jh, Jb, Ja, Ji, Ke, Kf, Kg, Lc, Ld, Le, Kh, Kd, Ke, Kb and Kc.

Biophysical Site Description

These systems occur on glacial lakebeds and in depressions on glacial outwash and moraines (Curtis 1959). The community frequently occurs along the margins of lakes and streams where seasonal flooding or beaver-induced flooding is common.

The soils are typically organic sediments (Curtis 1959) but saturated mineral soil may also support the community (Costello 1936). Because of the calcareous nature of the glacial drift in the regions occupied by these systems, wet soils contain high levels of dissolved minerals such as calcium and magnesium and pH values are frequently circum neutral to strongly alkaline (6.5-8.5) (Warners 1993, Curtis 1959, Costello 1936).

These systems typically occur in large wetland complexes and may be comprised of several different wetland communities. Where ground water seepage occurs at the bases of moraines, sedge meadow (southern wet meadow) may border calcareous fen (prairie fen), with shrub-carr and emergent marsh occurring in well-drained or poorly drained areas, respectively. In depressions on ground moraine or lakeplain, sedge meadow may grade into wet prairie, lakeplain wet prairie and shrub-carr up slope, and emergent marsh in lower areas. On the edges of inland lakes, sedge meadow and calcareous fen often border emergent marsh. These systems may also occur along the Great Lakes shoreline within extensive

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areas of Great Lakes marsh. In all of these landscape settings, sedge meadow may border shrub-carr and swamp forest.

Vegetation Description

These wetland systems include southern wet meadow, prairie fen and southern shrub-carr (MNFI 2003). Southern wet meadow is typically dominated by Carex stricta (Kost and De Steven 2000, Warners 1997, Curtis 1959, Costello 1936, Stout 1914). Because the roots of Carex stricta form large hummocks or tussocks, the species is responsible for the community's hummock and hollow structure. Individual culms of Carex stricta grow from the tussocks, which may reach more than one meter in height and 0.5m in diameter and live for more than 50yrs (Costello 1936). The Carex stricta tussocks can occur at very high densities (1-4 per m2) and occupy more than 40% of a meadow's area (Costello 1936). Because the shaded areas between tussocks are often covered with standing water and leaf litter, many of the shorter species inhabiting southern wet meadows grow almost exclusively from the sides or tops of Carex stricta tussocks.

Other sedges that commonly occur in southern wet meadow include: Carex aquatilis, C. comosa, C. bebbii, C. hystericina, C. lacustris, C. lanuginosa, C. lasiocarpa, C. prairea, C. rostrata, C. sartwellii, C. stipata and C. vulpinoidea. Although most of the associated sedge species tend to be randomly interspersed, Carex lacustris often occurs in dense patches.

The most dominant grass species in southern wet meadow is blue joint grass (Calamagrostis canadensis) (Kost and De Steven 2000, Stout 1914). Other common grasses include: fringed brome (Bromus ciliatus), fowl manna grass (Glyceria striata), marsh wild timothy (Muhlenbergia glomerata), leafy satin grass (Muhlenbergia mexicana) and fowl meadow grass (Poa palustris).

A wide variety of wetland forbs occur in southern wet meadow including, Aster puniceus, A. firmus, Campanula aparinoides, Asclepias incarnata, Cicuta bulbifera, Cirsium muticum, Eleocharis erythropoda, Eupatorium perfoliatum, Eupatorium maculatum, Galium asprellum, Impatiens capensis, Lycopus uniflorus, Mentha arvensis, Onoclea sensibilis, Pilea pumila, Polygonum amphibium, Pycnanthemum virginianum, Rumex orbiculatus, Solidago gigantea, Scutellaria galericulata, Sagittaria latifolia, Solidago patula, Thalictrum dasycarpum, Thelypteris palustris, Thelypteris palustris, Triadenum fraseri, Typha latifolia and Viola cucullata.

Prairie fens typically contain several distinct vegetation zones, which may include emergent marsh, marl flat, sedge meadow and wooded fen. The zones correspond to differing levels of groundwater influence and alkalinity and past natural and anthropogenic disturbances.

Emergent marsh can occur in low, level areas and near the margins of streams and lakes. Dominant species in this zone include Scirpus acutus (hardstem bulrush), Scirpus americanus (three-square), Carex lacustris, C. aquatilis (sedges), wide-leaved cattail (Typha latifolia) and arrowhead (Sagittaria latifolia).

Sedge meadow is typically the largest vegetative zone of a prairie fen and is dominated by sedges, grasses, low shrubs and a variety of forbs. Sedge meadow may occur in low, level areas and on slopes, where it often assumes an overall shorter stature. Characteristic sedges include Carex stricta (tussock sedge), C. sterilis, C. lasiocarpa, C. buxbaumii, C. prairea, and 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), blue-joint grass (Calamagrostis canadensis) and slender wheatgrass (Agropyron trachycaulum). Low shrubs occurring within the sedge

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meadow zone include shrubby cinquefoil (Potentilla fruticosa), alder-leaved buckthorn (Rhamnus alnifolia), sage willow (Salix candida), meadowsweet (Spiraea alba), and Betula pumila (bog birch). Common forbs include Eupatorium maculatum (joe-pye weed), E. perfoliatum (common boneset), 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), Rudbeckia hirta (black-eyed susan), Solidago ohioensis (Ohio goldenrod), Riddell's goldenrod (S. riddellii), bog goldenrod (S. uliginosa), sensitive fern (Onoclea sensibilis) and Thelypteris palustris (marsh fern).

Marl flats are a distinct feature of fens, forming in areas of calcareous groundwater seepage. Marl flats may occur as small pools or as extensive, level areas. In the later, low peat ridges that support sphagnum mosses (Sphagnum spp.), pitcher plant (Sarracenia purpurea), and stunted tamarack (Larix laricina) may be interspersed throughout the broad marl flats. Because the alkaline conditions permit few species to survive, marl flats are sparsely vegetated. Species occurring within marl flats include the following: sedges (Carex flava, C. leptalea, and C. sterilis), bog lobelia (Lobelia kalmii), 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), spike- rush (Eleocharis rostellata), white lady's slipper (Cypripedium candidum) and white camas (Zigadenus glauca), and carnivorous plants such as round-leaved sundew (Drosera rotundifolia), pitcher plant, flat-leaved bladderwort (Utricularia intermedia) and horned bladderwort (U. cornuta).

In the absence of fire and beaver flooding, the wooded fen zone probably occupies a significantly greater area within the remaining prairie fens than in the past. Woody species commonly occurring include Toxicodendron vernix (poison sumac), silky dogwood (Cornus amomum) C. foemina (gray dogwood), C. stolonifera (red-osier dogwood), Michigan holly (Ilex verticillata), Physocarpus opulifolius (ninebark), bog birch, nannyberry (Viburnum lentago), tamarack (Larix laricina), yellow birch (Betula alleghaniensis), Acer rubrum (red maple) and Ulmus americana (American elm). The area occupied by the wooded fen zone represents portions of the fen that are succeeding to closed-canopy communities such as southern shrub-carr and relict conifer swamp in the absence of natural disturbance and management. As such, many of the herbaceous species from the other zones also occur within wooded fen.

Shrub-carr commonly supports three distinct vegetation layers (White 1965). The most pronounced is the shrub layer, which typically exhibits little stratification or layering, and ranges in height from 5-18ft (ave. 8.6ft) (White 1965). Common species in the shrub layer include bog birch (Betula pumila), dogwoods (Cornus foemina, C. stolonifera, C. amomum), Michigan holly (Ilex verticillata), elderberry (Sambucus canadensis) and willows (Salix bebbiana, S. discolor, S. exigua, S. petiolaris and S. eriocephala). 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 such as water-plantain (Alisma plantago-aquatica), swamp milkweed (Asclepias incarnate), bluejoint grass (Calamagrostis canadensis), water hemlock (Cicuta maculate), water horsetail (Equisetum fluviatile), marsh fleabane (Erigeron philadelphicus), common boneset (Eupatorium perfoliatum), rattlesnake grass (Glyceria canadensis), wild bergamot (Monarda fistulosa), old-field simplex (Potentilla simplex), pasture rose (Rosa carolina), softstem bulrush (Schoenoplectus tabernaemontani), bulrush (Scirpus pendulus), Canada goldenrod (Solidago canadensis), and marsh fern (Thelypteris palustris). There may also be a third vegetative layer of smaller herbaceous species such as bedstraw (Galium spp.), clearweed (Pilea pumila), northern bugle weed (Lycopus uniflorus) and marsh bellflower (Campanula aparinoides). Overall, the vegetation of shrub-carr is highly variable due to frequent disturbances and small-scale

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differences in micro-topography, soil moisture and nutrient availability (White 1965).

Disturbance Description

These wetland systems are groundwater-dependent. Water levels fluctuate seasonally, reaching their peak in spring and lows in late summer (Warners 1993, Costello 1936). However, water levels typically remain at or near the soil's surface throughout the year (Warners 1993, Curtis 1959, Costello 1936). For southern wet meadows, in addition to seasonal flooding, 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 may also help create new southern wet meadows by flooding swamp forests and shrub-carr and thus, creating suitable habitat for the growth of shade-intolerant wet meadow species such as Carex stricta.

Evidence from wetland peat cores and circa 1800s maps indicate that southern wet meadow is a fire-dependent natural community (Davis 1979, Curtis 1959). Analysis of wetland peat cores shows that charcoal fragments are consistently associated with sedge and grass pollen (Davis 1979). Conversely, charcoal fragments are lacking from sections of peat cores dominated by shrub pollen. In southern WI, where prevailing westerly winds carry fires eastward, southern wet meadow frequently occurred adjacent to fire-dependent natural communities such as oak savannas and prairies on the west side (i.e., windward) of large rivers. While directly east (i.e., leeward) of these same rivers, similar topography supported fire-intolerant tamarack swamps and mesic forests (Zicker 1955 in Curtis 1959).

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 (Kost and De Steven 2000, Warners 1997). Fire also plays a critical role in preventing declines in species richness in many community types by creating micro-niches for small species (Leach and Givnish 1996). Another critically important attribute of fire for maintaining open southern wet meadow is its ability to temporarily reduce shrub cover (Reuter 1986).

In the absence of fire or flooding, all but the wettest southern wet meadows typically convert to shrub-car and eventually swamp forest (Curtis 1959). Because many of the species that inhabit southern wet meadow are shade-intolerant, species richness usually declines following shrub and tree invasion (White 1965, Curtis 1959).

Adjacency or Identification Concerns

These communities may occur within depressions surrounded by either fire-dependent uplands such as oak barrens, oak-pine barrens, oak openings, and dry oak forests or surrounded by systems in which fire is thought to be very infrequent such as southern mesic forest (sugar maple - American beech, basswood forest). Thus, fire frequency within the graminoid-dominated wetlands is strongly influenced by vegetation composition of adjacent uplands.

Native Uncharacteristic Conditions

Scale Description

Issues/Problems

The timeframe of the model (1000yrs) does not allow for an adequate description of hydrarch succession. Also, the diversity of herbaceous wetland communites is not fully described within the models created for these map zones (41, 50 and 51).

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Comments

Much of the text was taken directly from the Michigan Natural Features Inventory Natural Community Abstract for southern wet meadow (Kost 2001). Additionally, the prairie fen and shrub-carr portions of the Vegetation Description were modified from draft community descriptions by M. Kost and R. Schillo, respectively for updates to the MNFI Community Classification for Michigan.

Vegetation Classes

Class A 8 %

Early Development 1 Open

Upper Layer Lifeform

- [x] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model

Indicator Species* and Canopy Position

SALA2	Lower
POCO14	Lower
TYLA	Lower
CAST8	Lower

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	20 %
Height	Herb 0m	Herb 0.5m
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform.

Description

This class represents a beaver meadow with emergent marsh vegetation. This is an early seral stage with open water and emergent vegetation such as Sagittaria latifolia, Pontedaria cordata, Nuphar variegata and Typha latifolia. Absence of flooding was represented in this class by AltSuccession with a probability of 0.05 (20yrs) and would move the system to class B. Absence of flooding can be caused by periodic drought or local extirpation of beaver due to trapping or predation by wolves.

Class B 60 %

Late Development 1 Open

Upper Layer Lifeform

- [x] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model

Indicator Species* and Canopy Position

CAST8	Lower
CAAQ	Lower
CACA4	Lower
EUMA6	Lower

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	20 %
Height	Herb 0.6m	Herb >1.1m
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform.

Description

This class represents sedge-dominated wet meadow (sedge meadow) and prairie fen (calcareous fen), which is dominated by Carex stricta and other sedges along with bluejoint grass (Calamagrostis canadensis), and other grasses, rushes, and forbs. Frequent replacement fires (every 10yrs) and seasonal flooding (represented by Wind/Weather/Stress at 0.5 probability, every two years) help to maintain this class in an open condition and the structural and species diversity. Beaver flooding resulting in setting-back succession to emergent marsh or beaver meadow was represented by Option1 with a probability to 0.005 (200yrs). In the absence of natural disturbance, which is represented by AltSuccession, shrubs colonize the open meadow and result in succession to shrub-carr (class C) in 60yrs.

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Class C 27 %

Late Development 2 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☑ Shrub
- ☐ Tree

Fuel Model

Indicator Species* and Canopy Position

COFO	Middle
COAM2	Middle
SALA2	Middle
ILVE	Middle

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	61 %	100 %
Height	Shrub 0m	Shrub >3.1m
Tree Size Class	None	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Class C represents shrub-carr, a shrub-dominated wetland comprised of dogwoods (Cornus foemina, C. stolonifera, C. amomum), Michigan holly (Ilex verticillata), elderberry (Sambucus canadensis) and willows (Salix bebbiana, S. discolor, S. exigua, S. petiolaris and S. eriocephala). The ground layer of shrub-carr is typically diverse with a mix of wet meadow and forested wetland vegetation. Many of the sedges formerly abundant in class B (sedge meadow) continue to be present but in a relatively suppressed condition due to the lower light levels under the cover of shrubs. Option1 represents severe beaver-flooding with a probability of 0.005 (200yrs) and the creation of a beaver pond with emergent marsh vegetation (class A). Option2 represents less severe beaver-flooding with a probability of 0.02 (50yrs), which results in shrub mortality and the release of suppressed sedges and creation of a sedge meadow (class B). Seasonal flooding as well as years of high water or drought are represented by Wind/Weather/Stress with a probability of 0.1 (10yrs) and help maintain structural and species diversity.of this class In the absence of beaver flooding, trees become established and the community succeeds to swamp forest (class D) after 80yrs.

Class D 5 %

Late Development 3 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

LALA	Upper
PIST	Upper
ACRU	Upper
FRNI	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	61 %	100 %
Height	Tree 10.1m	Tree 25m
Tree Size Class	Medium 9-21"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

This class represents swamp forest, which may be dominated by conifers, hardwoods, or a mix of both. Dominant tree species may include tamarack (Larix laricina), white pine (Pinus strobus), black ash (Fraxinus nigra), American elm (Ulmus americana), red maple (Acer rubrum), silver maple (Acer saccharinum), and yellow birch (Betula allegheniensis). Windthrow, seasonal flooding, and years of high water or drought are represented by Wind/Weather/Stress with a probability of 0.1 (10yrs) and help maintain structural and species diversity of this class. Option1 represents severe beaver-flooding with a probability of 0.005 (200yrs) and the creation of a beaver pond with emergent marsh vegetation (class A). Option2 represents less severe beaver-flooding with a probability of 0.02 (50yrs), which results in shrub mortality and the release of suppressed sedges (e.g., class B, sedge meadow).

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Class E **0 %**

[Not Used] [Not Used]

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☐ Tree

Fuel Model

Description

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	%	%
Height		
Tree Size Class		

☐ Upper layer lifeform differs from dominant lifeform.

Disturbances

Fire Regime Group: II**

Historical Fire Size (acres)

Avg 0
Min 0
Max 0

Sources of Fire Regime Data

- ☐ Literature
- ☐ Local Data
- ☑ Expert Estimate

Fire Intervals

	Avg FI	*Min FI*	*Max FI*	*Probability*	*Percent of All Fires*
Replacement	16.37			0.0611	100
Mixed					
Surface					
All Fires	16			0.06112	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fir combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inver of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- ☐ Insects/Disease
- ☑ Wind/Weather/Stress
- ☐ Native Grazing
- ☐ Competition
- ☑ Other (optional 1) severe beaver flooding
- ☑ Other (optional 2) less severe beaver flooding

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LANDFIRE Biophysical Setting Model

***Biophysical Setting* 5014940** **Laurentian-Acadian Shrub-Herbaceous Wetland Systems**

☐ *This BPS is lumped with:*
☐ *This BPS is split into multiple models:*

General Information

Contributors (also see the Comments field **Date** 4/10/2007

Modeler 1 Michael A. Kost kostmi@msu.edu **Reviewer** Dave Cleland dcleland@fs.fed.us
Modeler 2 **Reviewer**
Modeler 3 **Reviewer**

Vegetation Type
Wetlands/Riparian

Map Zone
50

Model Zone
☐ Alaska ☐ N-Cent.Rockies
☐ California ☐ Pacific Northwest
☐ Great Basin ☐ South Central
☑ Great Lakes ☐ Southeast
☐ Northeast ☐ S. Appalachians
☐ Northern Plains ☐ Southwest

Dominant Species*
CAST8 SALA2
CACA4 ALIN2
THOC2 BEPU4
CALA11

General Model Sources
☑ Literature
☐ Local Data
☑ Expert Estimate

Geographic Range

These systems occur throughout the upper Great Lakes region in Ontario, Canada, and MI, MN and WI. In MZs 41, 50 and 51, it occurs throughout section 212.

Biophysical Site Description

These systems occur on glacial lakebeds, in channels of glacial outwash, and in depressions on glacial outwash and moraines (NatureServe 2005a, NatureServe 2005b, Hoffman 2002, Faber-Langendoen 2001, Reuter 1986, Curtis 1959). They frequently occur along the margins of lakes, ponds and streams where seasonal flooding or beaver-induced flooding is common (Hoffman 2002, Reuter 1986, Curtis 1959).

These systems typically occur on organic soil such as well-decomposed sapric peat (Curtis 1959) but saturated mineral soil may also support these systems (NatureServe 2005a, Hoffman 2002, Faber-Langendoen 2001, Curtis 1959) Soil pH may range from strongly acid to circum neutral (Warners 1993, Curtis 1959, Costello 1939).

These systems often occur as large wetland complexes comprised of northern emergent marsh, northern wet meadow (sedge meadow), northern fen (boreal rich fen), northern shrub thicket, and swamp forest (rich conifer swamp, northern swamp, hardwood-conifer swamp). Northern wet meadow and northern fen (sedge meadow) may occur along streams and the grade into northern shrub thicket and swamp forest (Curtis 1959). On the edges of inland lakes, northern wet meadow often borders emergent marsh and less frequently northern fen. These wetland communities may also occur along the Great Lakes shoreline within extensive areas of Great Lakes marsh.

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Vegetation Description

These wetland systems may include emergent marsh, northern wet meadow, northern fen, northern shrub thicket and swamp forest (MNFI 2003).

Northern wet meadow is a sedge-dominated system that typically has 100% vegetative cover in the ground layer (Eggers and Reed 1997, Curtis 1959). Sedge meadow is often dominated by Carex stricta (tussock sedge) (Kost and De Steven 2000, Warners 1997, Curtis 1959, Costello 1936, Stout 1914). Because the roots of Carex stricta form large hummocks or tussocks, the species is often responsible for the community's hummock and hollow structure. Individual culms of Carex stricta grow from the tussocks, which may reach more than one meter in height and half a meter in diameter and live for more than 50yrs (Costello 1936). The Carex stricta tussocks can occur at very high densities (1-4 per m2) and occupy more than 40% of a meadow's area (Costello 1936). Because 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.

Other sedges that commonly occur in northern wet meadow include: Carex aquatilis (water sedge), C. bebbii (Bebb's sedge), C. buxbaumii (Buxbaum's sedge), C. comosa (long-hair sedge), C. hystericina (bottlebrush sedge), C. lacustris (lake or hairy sedge), C. lanuginose (woolly sedge), C. lasiocarpa (wiregrass sedge), C. rostrata (beaked sedge), C. stipata (saw-beak sedge), C. vesicaria (blister sedge) and C. vulpinoidea (fox sedge). Although most of the associated sedge species tend to be randomly interspersed, Carex lacustris, C. lasiocarpa, C. rostrata and C. vesicaria can often occur as dominants or co-dominants.

The most dominant grass species in northern wet meadow is Calamagrostis canadensis (blue-joint grass) (Kost and De Steven 2000, Stout 1914). Other common grasses include: Bromus ciliatus (fringed brome), Glyceria canadensis (manna grass), G. striata (fowl manna grass), Muhlenbergia glomerata (marsh wild timothy), Muhlenbergia mexicana (leafy satin grass), and Poa palustris (fowl meadow grass). Spike-rushes (i.e., Eleocharis erythropoda), cat-tails (Typha latifolia and Typha angustifolia), Cladium marisicoides (twig-rush) and Scirpus atrovirens (green bulrush) are also common graminoids. Sedge meadows disturbed by agricultural use, grazing, drainage and/or filling are frequently dominated by Phalaris arundinaceae (reed canary grass), an extremely aggressive grass that forms persistent, monotypic stands (Eggers and Reed 1997).

A wide variety of wetland forbs occur scattered in northern wet meadow. Due to the high moisture conditions during the spring, many of the forbs bloom in the summer and fall (Curtis 1959). The following are some of the more common species: Anemone canadensis (Canada anemone), Asclepias incarnata (swamp milkweed), Aster lanceolatus (panicled aster), A. lateriflorus (calico aster), A. puniceus (swamp aster), A. umbellatus (flat-topped aster), Campanula aparinoides (marsh bellflower), Cicuta bulbifera (water-hemlock), C. maculata (water-hemlock), Cirsium muticum (swamp thistle), Epilobium strictum (downy willowherb), Eupatorium maculatum (Joe-pye-weed), Eupatorium perfoliatum (boneset), Euthamia graminifolia (flat-topped goldenrod), Galium asprellum (rough bedstraw), G. trifidum (threepetal bedstraw), Impatiens capensis (spotted touch-me-not), Iris versicolor (wild blue flag), Lathyrus palustris (marsh pea), Lycopus americanus (American water-horehound), L. uniflorus (northern bugleweed), Lysimachia thyrsifolia (tufted loosestrife), Mentha arvensis (wild mint), Polygonum amphibium (water smartweed), Rumex orbiculatus (greater water dock), Sagittaria latifolia (duck-potato or common arrowhead), Scutellaria galericulata (marsh skullcap), Solidago canadensis (Canada goldenrod), S. gigantea (late goldenrod), S. patula (rough-leaved goldenrod or swamp goldenrod), Thalictrum dasycarpum (purple meadow-rue), Triadenum fraseri (marsh St. John's-wort), Verbena

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hastata (blue vervain) and Viola cucullata (marsh violet). Characteristic fern or fern allies include Dryopteris cristata (crested woodfern), Equisetum arvense (field horsetail), E. fluviatile (water horsetail), Onoclea sensibilis (sensitive fern) and Thelypteris palustris (marsh fern).

Northern wet meadow can also contain numerous, scattered shrub and tree species. Shrub and tree encroachment is especially pronounced in sites that have altered flooding or fire regimes. Prevalent shrubs include Alnus rugosa (speckled alder), Betula pumila (bog birch), Cornus stolonifera (red-osier dogwood), Potentilla fruticosa (shrubby cinquefoil), P. palustris (marsh cinquefoil), Salix spp. (willows), Spiraea alba (meadowsweet) and S. tomentosa (steeplebush). Scattered trees and tree saplings are often found invading northern wet meadow. Typical tree species include Acer rubrum (red maple), Fraxinus nigra (black ash), Larix laricina (tamarack), Populus balsamifera (balsam poplar), Populus tremuloides (quaking aspen) and Thuja occidentalis (northern white cedar). (Above species lists compiled from Michigan Natural Features Inventory database, NatureServe 2005a, Faber-Langendoen 2001, Eggers and Reed 1997, Reuter 1986, Curtis 1959).

Northern shrub thicket vegetation is characterized by an overwhelming dominance of speckled alder, which forms dense (often monotypic) thickets with canopy coverage ranging between 40-95% and stand height typically between one and 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 more diversity being found in the 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: Aster puniceus (swamp aster), Caltha palustris (marsh marigold), Campanula aparinoides (marsh bellflower), Eupatorium maculatum (Joe-pye-weed), E. perfoliatum (boneset), Galium asprellum (rough bedstraw), Impatiens capensis (spotted touch-me-not), Iris versicolor (wild blue flag), Lycopus uniflorus (northern bugleweed or water-horehound), Mentha arvensis (wild mint), Mimulus ringens (monkey-flower), Scutellaria galericulata (marsh skullcap), S. lateriflora (mad-dog skullcap), Senecio aureus (golden ragwort), Solidago canadensis (Canada goldenrod), S. gigantea (late goldenrod), S. rugosa (rough-leaved goldenrod), Symplocarpus foetidus (skunk cabbage) and Thalictrum dasycarpum (purple meadow-rue). Characteristic ferns and fern allies include Equisetum arvense (field horsetail), Onoclea sensibilis (sensitive fern), Osmunda cinnamomea (cinnamon fern), O. regalis (royal fern) and Thelypteris palustris (marsh fern). Short shrubs include Myrica gale (wax-myrtle or bayberry), Potentilla palustris (marsh cinquefoil), Ribes americanum (wild black currant), Rubus hispidus (swamp dewberry), R. pubescens (dwarf raspberry), R. strigosus (wild red raspberry) and Spirea alba (meadowsweet). Where alder does not form a monospecific shrub layer, associates of the tall shrub layer can include Aronia prunifolia (chokeberry), Betula pumila (bog birch), Cornus amomum (silky dogwood), C. stolonifera (red-osier dogwood), Ilex verticilata (winterberry), Salix bebbiana (Bebb's willow), S. discolor (pussy willow), S. exigua (sandbar willow), S. petiolaris (slender willow), Viburnum cassinoides (wild-raisin) and V. opulus (highbush-cranberry). Scattered trees and tree saplings are often found invading northern shrub thickets. Typical tree species include balsam fir, red maple, black ash, tamarack, black spruce, balsam poplar, quaking aspen, and white pine and northern white cedar.

Disturbance Description

These wetland systems are groundwater-dependent. Water levels fluctuate seasonally, reaching their peak in spring and lows in late summer (Warners 1993, Costello 1936). However, water levels typically remain at or near the soil's surface throughout the year (Eggers and Reed 1997, Warners 1993, Curtis 1959, Costello 1936). For northern wet meadows, in addition to seasonal flooding, beaver-induced flooding may also play an important role in maintaining the community by occasionally raising water levels and killing

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encroaching trees and shrubs. Beaver may 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.

Evidence from wetland peat cores and circa 1800 vegetation maps indicate that wet meadow is a fire-dependent natural community (Davis 1979, Curtis 1959). Analysis of wetland peat cores shows that charcoal fragments are consistently associated with sedge and grass pollen (Davis 1979). Conversely, charcoal fragments are lacking from sections of peat cores dominated by shrub pollen. Fires typically occur in sedge meadows during dry conditions of early spring or late fall (White 1965). 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 (Kost and De Steven 2000, Warners 1997). Fire also plays a critical role in preventing declines in species richness in many community types by creating micro-niches for small species (Leach and Givnish 1996). In the absence of fire, a thick layer of leaf litter can develop that stifles seedling establishment and seed bank expression. Another critically important attribute of fire for maintaining open sedge meadow is its ability to temporarily reduce shrub cover (Hoffman 2002, Reuter 1986, White 1965). In the absence of fire or flooding, all but the wettest sedge meadows typically convert to shrub thicket and eventually swamp forest (Curtis 1959). Because many of the species that inhabit wet meadow are shade-intolerant, species richness usually declines following shrub and tree invasion (Reuter 1986, White 1965, Curtis 1959).

Adjacency or Identification Concerns

These communities may occur within depressions surrounded by either fire-dependent uplands such as pine barrens, oak-pine barrens and mixed pine systems (dry- and dry-mesic northern forest) or systems in which fire is thought to be very infrequent such as northern mesic forest (northern hardwood forest - sugar maple, American beech, basswood and eastern hemlock). Thus, fire frequency within the graminoid-dominated wetlands is strongly influenced by vegetation composisition of adjacent uplands.

Native Uncharacteristic Conditions

Scale Description

Issues/Problems

The timeframe of the model (1000yrs) does not allow for an adequate description of hydrarch succession. Also, the diversity of herbaceous wetland communities is not fully described within the models created for these map zones (41, 50 and 51).

Comments

Much of the text was taken directly from the Michigan Natural Features Inventory Natural Community Abstract for Northern Wet Meadow (Cohen and Kost 2005). Additionally, the Vegetation Description for northern shrub thicket was modified from the Michigan Natural Features Inventory Natural Community Abstract for Northern Shrub Thicket (Cohen 2005).

Vegetation Classes

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100-year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement seve

Class A 9 %

Early Development 1 Open

Upper Layer Lifeform

- [x] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model

Indicator Species* and Canopy Position

SALA2	Lower
POCO14	Lower
TYLA	Lower
CAST8	Lower

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	20 %
Height	Herb 0m	Herb 0.5m
Tree Size Class	None	

☐ Upper layer lifeform differs from dominant lifeform.

Description

This class represents a beaver meadow with emergent marsh vegetation. This is an early seral stage with open water and emergent vegetation such as Sagittaria latifolia, Pontedaria cordata, Nuphar variegata, Carex stricta and Typha latifolia. Absence of flooding was represented in this class by AltSuccession with a probability of 0.05 (20yrs). Absence of flooding can be caused by periodic drought or local extirpation of beaver due to trapping or predation by wolves.

Class B 58 %

Late Development 1 Open

Upper Layer Lifeform

- [x] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model

Indicator Species* and Canopy Position

CAST8	Lower
CACA4	Lower
CAAQ	Lower
EUMA6	Lower

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	20 %
Height	Herb 0.6m	Herb >1.1m
Tree Size Class	None	

☐ Upper layer lifeform differs from dominant lifeform.

Description

This class represents sedge-dominated northern wet meadow (northern sedge meadow) and northern fen (boreal rich fen), which is dominated by Carex stricta or Carex lasiocarpa and other sedges along with bluejoint grass (Calamagrostis canadensis), and other grasses, rushes, and forbs. Frequent replacement fires (every 10yrs) and seasonal flooding (represented by Wind/Weather/Stress at 0.5 probability, every two years) help to maintain open conditions and structural and species diversity. Beaver flooding resulting in setting-back succession to emergent marsh or beaver meadow was represented by Option1 with a probability to 0.005 (200yrs). In the absence of disturbance, which is represented by AltSuccession, shrubs colonize the open meadow and result in succession to shrub-carr in 60yrs.

Class C 28 %

Late Development 2 Closed

Upper Layer Lifeform

- [ ] Herbaceous
- [x] Shrub
- [ ] Tree

Fuel Model

Indicator Species* and Canopy Position

ALIN2	Middle
BEPU4	Middle
ILVE	Middle
CACA4	Lower

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	61 %	100 %
Height	Shrub 1.1m	Shrub >3.1m
Tree Size Class	None	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Class C represents northern shrub thicket, a type dominated by tag alder (Alnus incana). Other shrubs such as bog birch (Betula pumila), Michigan holly (Ilix veticillata) and meadow sweet (Spirea alba). The ground layer of shrub-carr is typically diverse with a mix of wet meadow and forested wetland vegetation. Many of the sedges formerly abundant in class B (sedge meadow) continue to be present but in a relatively suppressed

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condition due to the lower light levels under the cover of alser and other shrubs. In the absence of beaver flooding, trees become established within 100yrs and the community succeeds to swamp forest. Seasonal flooding as well as years of high water and drought are represented by Wind/Weather/Stress with a probability of 0.1 (10yrs). Option1 represents severe beaver-flooding with a probability of 0.005 (200yrs) and the creation of a beaver pond with emergent marsh vegetation (class A). Option2 represents less severe beaver-flooding with a probability of 0.02 (50yrs), which results in shrub mortality and the release of suppressed sedges (e.g., class B, sedge meadow).

Class D **5 %**

Late Development 3 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

THOC2	Upper
FRNI	Upper
PIST	Upper
BEAL2	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	61 %	100 %
Height	Tree 10.1m	Tree 25m
Tree Size Class	Medium 9-21"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

This class represents swamp forest, which is typically dominated by conifers, especially northern white-cedar (Thuja occidentalis). However, hardwoods or a mix of both hardwoods and conifers may be dominant including tamarack (Larix laricina), white pine (Pinus strobus), black ash (Fraxinus nigra), American elm (Ulmus americana), red maple (Acer rubrum) and yellow birch (Betula allegheniensis). Seasonal flooding as well as years of high water and drought are represented by Wind/Weather/Stress with a probability of 0.1 (10yrs). Option1 represents severe beaver-flooding with a probability of 0.005 (200yrs) and the creation of a beaver pond with emergent marsh vegetation (class A). Option2 represents less severe beaver-flooding with a probability of 0.02 (50yrs), which results in shrub mortality and the release of suppressed sedges (e.g., class B, sedge meadow).

Class E **0 %**

[Not Used] [Not Used]

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☐ Tree

Fuel Model

Indicator Species* and Canopy Position

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	%	%
Height		
Tree Size Class		

☐ Upper layer lifeform differs from dominant lifeform.

Description

Disturbances

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Fire Regime Group:** IV

Historical Fire Size (acres)

Avg 0
Min 0
Max 0

Sources of Fire Regime Data

- [ ] Literature
- [ ] Local Data
- [x] Expert Estimate

Fire Intervals	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	180.1			0.00555	100
Mixed					
Surface					
All Fires	180			0.00557	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inver of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- [ ] Insects/Disease
- [x] Wind/Weather/Stress
- [ ] Native Grazing
- [ ] Competition
- [x] Other (optional 1) severe beaver flooding
- [x] Other (optional 2) less severe beaver flooding

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100-year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement seve

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100-year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement seve

LANDFIRE Biophysical Setting Model

Biophysical Setting 5015170 Paleozoic Plateau Bluff and Talus

☐ *This BPS is lumped with:*
☐ *This BPS is split into multiple models:*

General Information

Contributors (also see the Comments field **Date** 7/9/2007

Modeler 1	Brendan C. Ward	bward@fs.fed.us	**Reviewer**
Modeler 2	Jim Drake	jim_drake@natureserve.org	**Reviewer**
Modeler 3			**Reviewer**

Vegetation Type
Forest and Woodland

Map Zone
50

Model Zone
☐ Alaska ☐ N-Cent.Rockies
☐ California ☐ Pacific Northwest
☐ Great Basin ☐ South Central
☑ Great Lakes ☐ Southeast
☐ Northeast ☐ S. Appalachians
☐ Northern Plains ☐ Southwest

Dominant Species*

JUVI	QUVE
QUAL	PIST
QURU	QUMU
QUMA2	SCSC

General Model Sources
☑ Literature
☐ Local Data
☑ Expert Estimate

Geographic Range

This system is found in the region of southeastern MN, southwestern WI, and northern IA and IL that has escaped recent glaciation. This region is also known as the "driftless area." It is especially prevalent along the Mississipi and Wisconsin Rivers and tributaries within this region.

In LANDFIRE MZs 41 and 50, this system is geographically limited to section 222L.

Biophysical Site Description

This system is found predominantly on dry bluff tops, upper slopes, cliffs and talus fields in the “driftless area” of MN, WI, IA and IL (Section 222L). Characteristic substrate conditions are loess-covered dolomite caps over sandstone (Kline and Cottam 1979). The juxtaposition of more slowly-eroding dolomite over easily eroded sandstone creates deeply-dissected terrain and fairly steep slopes. Bedrock is primarily sedimentary dolomite, limestone, and sandstone of Paleozoic origin, but also includes quartzite of Proterozoic (Precambrian) origin in the Baraboo Hills of Wisconsin.

Soils range from thin to moderately deep primarily loess deposits and can range from moderately to excessively well-drained, often with a high mineral content. Slopes range from extremely steep on cliffs to moderate on mid and upper slopes to nearly flat on bluff tops.

A combination of landform, slope and bedrock geology is most likely required for mapping this system. In particular, limiting this system to sites where landform indicates ridgetops, upper slopes, or where slopes exceed 30-40% in Section 222L would capture the main distribution of this system.

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Vegetation Description

This system is composed of several fairly distinct communities, the composition of which is primarily a function of site characteristics and landscape position. These communities are only partially linked by processes of succession and disturbance.

Dry and dry-mesic prairies primarily occurred on exposed south and west facing slopes and bluff tops where well-drained and often thin soils (McClain &nd Ebinger 2002) and high fire frequency would have limited establishment of trees. Characteristic species include Schizachyrium scoparium, Andropogon gerardii, Pulsatilla patens, Artemisia caudate, Oligoneuron album, Symphyotrichum pretense, Bouteloua curtipendula, Dichanthelium linearifolium, Solidago nemoralis, Lithospermum incisum, Amorpha canescens, Sporobolus heterolepis, Geum triflorum, Viola pedata and Dodecatheon meadia (Baskin and Baskin 2000, Curtis 1959, McClain and Ebinger 2002).

Red cedar glades, dominated by Juniperus virginiana, occurred on steep, rocky sites or other dry landscape positions where lower fire frequency would have permitted establishment of this fire sensitive species (Baskin & Baskin 2000). Understories of very open stands would have been occupied by the dry prairie species mentioned above, whereas closed stands would have had a poorly-developed understory due to the significant shade cast by the overstory (Curtis 1959).

Oak savannas and woodlands would have occurred on deeper soils on moderately-drained side slopes and bluff tops, where edaphic conditions would permit the establishment of tree species and where fire return intervals were short to moderate. A mixture of oaks was present on these sites, with Quercus alba (white oak) dominating across a wide range of conditions, Quercus velutina occasionally codominating, Quercus rubra (red oak) becoming more prevalent on more mesic loamier sites, and Quercus macrocarpa (bur oak) becoming more prevalent on blufftops with limestone substrates or on lower slopes bordering on broad valleys where fire frequency would have been sufficient to maintain savanna conditions (Curtis 1959, Kline and Cottam 1979, Wilde et al. 1948). Quercus muehlenbergii (chinkapin oak) would have occupied rocky exposed sites in the southern range of this system (Kline and Cottam 1979, Burns and Honkala 1990). Populus tremuloides (trembling aspen) and Populus grandidentata (bigtooth aspen) were present alongside the oaks on more mesic sites with indications of relatively recent 1qdisturbance (Kline and Cottam 1979). Carya ovata (shagbark hickory) was also occasionally present (Wilde et al. 1948).

Southern mesic hardwoods would have occurred on north and east facing slopes with deeper, loamier soils where landscape position would have provided protection from fire. Dominant species include Acer saccharum (sugar maple) and Tilia americana (basswood). Other codominant or occasional species include Quercus alba (white oak), Quercus rubra (red oak), Carya ovata (shagbark hickory), Carya cordiformis (bitternut hickory), Acer rubrum (red maple), Ulmus americana (elm), Celtis occidentalis (hackberry) and Ostrya virginiana (hop hornbeam) (Curtis 1959, Kline and Cottam 1979, Wilde et al. 1948).

Northern forest relicts, including Pinus strobus (white pine), Pinus resinosa (red pine), Pinus banksiana (jack pine), Tsuga canadensis (hemlock) and Betula alleghaniensis (yellow birch) primarily occupied sandstone outcrops, cliffs and deep ravines. The pines, primarily Pinus strobus, would have been especially prevalent on somewhat more exposed north and east facing sandstone outcrops (Ziegler 1995, Wilde et al. 1948) and cliffs with slopes over 40 degrees (Curtis 1959). Tsuga canadensis and Betula alleghaniensis would have been confined to sandstone outcrops in cool, protected coves and ravines.

Algific talus slopes occupy very unique and small-scale sites where limestone and dolomite talus or

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cracked bedrock facilitate cold air drainage throughout the growing season (Nekola 1999). Slopes tend to be steep and north-facing. The ground layer is dominated by bryophytes and pteridophytes, with overstories of Acer saccharum, Acer spicatum, Abies balsamea, Betula lutea, Betula papyrifera, Fraxinus americana, Juglans cinerea and Pinus strobus (Nekola 1999). This type is critical habitat for monkshood and the Pleistocene snail, among other endemic species.

Disturbance Description

Fire regimes ranged from frequent replacement (FRG II) in dry prairies to frequent surface (FRG I) in oak savannas and woodlands, to much less frequent (FRG IV and V) on rocky protected sites or narrow mesic ravines.

Adjacency or Identification Concerns

This system intergrades and can be confused with tallgrass prairie systems on moderate side slopes and bluff tops where contiguity of fine fuel permitted high fire frequencies, or on well-drained south and west slopes where establishment of forest systems was limited by edaphic conditions. This system can be distinguished from the tallgrass prairie types by occupying moderate to steep slopes and bluff tops with thin soils, which would lead to a drier, less productive prairie system than the tallgrass prairie types. More productive, deeper soils with high fire frequency, such as lower slopes, are more likely best represented by the tallgrass prairie systems instead of this system.

This system intergrades with North-Central Interior Dry Oak Forest and Woodland (1311) and North-Central Interior Oak Savanna (1394) on exposed south and west slopes with moderate to deep soils. It intergrades with North-Central Interior Dry-Mesic Oak Forest and Woodland (1310) on moderate to deep soils on more northerly or easterly aspects, and with North-Central Interior Maple-Basswood Forest (1314) on the most protected sites and lower mesic slopes.

This system also contains southern relics of more northerly systems, especially Laurentian-Acadian Northern Pine-Oak Forest (1362), Laurentian-Acadian Northern Hardwoods Forest (1302), and Laurentian-Acadian Pine-Hemlock-Hardwood Forest (1366). Where indicators of those systems are found in this subsections on steep slopes and bluff tops, they should be represented by this system.

Native Uncharacteristic Conditions

Anecdotal evidence suggests that Juniperus virginiana is able to readily invade dry and dry-mesic prairies near established seed sources where fire suppression has artificially lengthened fire return intervals (Baskin and Baskin 2000, Holthuijzen Sharik 1984). This has led to signficant increases in red cedar cover in sites that formerly would have lacked a significant woody component.

Many dry prairies and oak woodlands on flat ridgetops were historically converted into agricultural land uses. Lower slopes were also often converted to agriculture or pasture. The remaining sites are often very steep, or possess edaphic conditions that would have prevented agricultural land uses, such as very thin soil or rock outcroppings. Fire suppression has resulted in a major trend toward closed forest conditions, both red cedar as noted above, and oak and mesic woodlands on a larger scale.

Scale Description

This system occupies highly variable terrain, and can therefore range from small (<1ha) to quite large (>1000 contiguous ha). Due to the complex terrain, fires spreading through this system were likely limited to hillslope facets and generally small (<100ha).

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100-year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement seve

Issues/Problems

Little data is available on the functional processes of this system, especially fire. Much of the literature for this system was quite old (1930s-1950s), which may have limited the ecological detail described. In particular, no literature was available that stated fire frequencies or other disturbance rates except vaguely. Disturbance and succession rates were based on best guesses as to how this system may function in the larger landscape context of similar floristic systems.

This model was mysteriously absent form the final delivered model set for MZ50. Brendan Ward uploaded latest available copy. QA/QC or review was not conducted.

Comments

This model was based partly on fire probabilities derived from other systems with overlapping species, including 13100, 13110 and 13140. This model was developed several months after the main modeling workshops for MZs 41, 50 and 51 due to the late addition of this system to the LANDFIRE mapping legend.

Vegetation Classes

Class A **32 %**

Early Development 1 All Structure

Upper Layer Lifeform

- [x] Herbaceous
- [ ] Shrub
- [ ] Tree

Fuel Model

Indicator Species* and Canopy Position

SCSC	Upper
ANGE	Upper
BOCU	Upper
SONE	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	100 %
Height	Herb 0m	Herb 10.0m
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform.

Description

Dry Prairie:
This class would be dominated by herbaceous species, including Schizachyrium scoparium, Andropogon gerardii, Pulsatilla patens, Artemisia caudate, Oligoneuron album, Symphyotrichum pretense, Bouteloua curtipendula, Dichanthelium linearifolium, Solidago nemoralis, Lithospermum incisum, Amorpha canescens, Sporobolus heterolepis, Geum triflorum, Viola pedata and Dodecatheon meadia.

Succession is to C after 20yrs, on the premise that the xeric and relatively thin soils typified by this system would require greater recruitment time for the oaks than would be observed in oak systems in the valleys and glaciated areas to the east (BpS 13100 and 13110).

The transition to B was modeled using AltSuccession at annual rate of 0.005 to account for the establishment of Juniperus virginiana on more rocky, fire protected sites based on available seed sources. A time since disturbance pathway was not used to account for this transition because it is not deterministic given fire exclusion, but is rather limited by availability of seed sources, lack of fire, and site-specific conditions that would prevent the rapid establishment of oaks (class C); thus a slight annual probability was used to account for these combinations of factors.

Replacement fires, occurring every six years (p=0.166) would maintain this class. Native grazing was included at a probability of 0.001.

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Class B **8 %**

Mid Development 1 Open

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

JUVI	Upper
SCSC	Lower
BOCU	Lower

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	30 %
Height	Tree 0m	Tree 5m
Tree Size Class	None	

☑ Upper layer lifeform differs from dominant lifeform.

Herbaceous species may dominate this class with 10-70% herbaceous cover.

Description

Red Cedar Glade: This class would be dominated by red cedar (Juniperus virginiana) with a number of dry prairie species, especially Schizachyrium scoparium, Andropogon gerardii, Bouteloua curtipendula and Solidago nemoralis. This class would arise on rocky, fire protected sites, with available seed sources of red cedar. This class could also arise on somewhat less rocky dry prairie sites where fire frequency is sufficiently low to allow establishment of fire-intolerant red cedar, in addition to requiring that seed sources are available.

This class has the potential to transition to oak-dominated woodlands on some sites. This is modeled as AltSuccession to SClass C with an annual rate of 0.01. In the absence of disturbance, this class is self-perpetuating.

Replacement fires, occurring every 100yrs (p=0.01), would reset this class to A. While these class can occupy rocky, fire infrequent sites, its general proximity to frequent fire prairies would allow occasional fires to occur in this SClass. Wind/Weather/Stress transitioning to A was modeled as occurring every 1000yrs (p=0.001) given the exposed landscape position of these sites.

Class C **41 %**

Mid Development 2 Open

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

QUAL	Upper
QURU	Upper
QUVE	Upper
QUMA2	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	70 %
Height	Tree 0m	Tree 25m
Tree Size Class	None	

☐ Upper layer lifeform differs from dominant lifeform.

Herbaceous species may dominate this class under very open savanna conditions with 10-90% herbaceous cover.

Description

Oak Savanna and Woodland: This class would be dominated by Quercus alba, Quercus rubra, Quercus velutina and Quercus macrocarpa depending on site location, fire frequency, and soils. The cover of the oaks could range from very open to closed depending on fire frequency and stand development, in addition to soil suitabiilty. Stands on very steep slopes, very thin soils, or edges of bluffs would likely be more open, as would stands experiencing more frequent fire.

This class could be distinguished from D and E using EVT. This type could be mapped to the southern oak systems, including 2310, 2311 and 2394.

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*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100-year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement seve

This class was modeled with a 20yr fire return interval derived from the fire rates specified for BpS models 13100 and 13110. 50% of fires (p=0.025) are surface and 40% mixed (p=0.02), both of which maintain this class. Replacement fires occur 10% of the time (p=0.005) causing a transition to A. AltSuccession with a time-since-disturbance of 100yrs causes a transition to D.

This class has the potential to transition to E where seed sources are available and site conditions are suitable. This is modeled with an annual probability of 0.0005.

Class D **9 %**

Mid Development 3 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

ACSA3	Upper
TIAM	Upper
QURU	Upper
QUAL	

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	71 %	100 %
Height	Tree 10.1m	Tree 25m
Tree Size Class	None	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Southern Mesic Hardwoods: This class would be dominated by mesic to dry-mesic species depending on the site, especially Acer saccharum, Tilia americana and Quercus rubra. Quercus alba could be present as older individuals that established in class C. As closed canopy conditions persist, the oaks would become less frequent due to their inability to recruit under a closed canopy.

This class could be distinguished from C and E using EVT. This type could be mapped to 2314.

Replacement fire was modeled with a 500yr return interval (p=0.002), on the premise that the thinner, drier sois that typify this system would lead to less of the mesic forest fire deterrence effect noted for 13140, and thus some fires would be able to spread upslope from adjacent more frequent fire systems except on more mesic north-facing slopes. Wind/Weather/Stress with a transition to A was modeled with a 625yr return interval (p=0.0016).

Class E **10 %**

Late Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

PIST	Upper
BEAL2	Upper
TSCA	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	100 %
Height	Tree 5.1m	Tree 50m
Tree Size Class	None	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Northern Relict Forest: This class would be dominated by Pinus strobus on sandstone outcrops near suitable seed sources. Pinus resinosa and Pinus banksiana could be occasional associates in landscapes where sufficient seed sources exist. Betula alleghaniensis and Tsuga canadensis could establish on cool cove and ravine sandstone outcrops that are protected from fire and near suitable seed sources; however, these two species are rare to absent within the range of this system.

This class also includes algific talus slopes, with associated rare Pleistocene relict species.

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**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100-year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement seve

This class could be distinguished from classes C and D using EVT. This type could be mapped to northern forest EVTs such as 2303 (northern hardwoods including Betula alleghaniensis), 2362 (northern pines) and 2366 (Pinus strobus and Tsuga canadensis).

Replacement disturbances are rare in this type due to their generally protected landscape positions. Replacement fire, occurring on a 666yr return interval (p=0.0015) would reset this class to A. Wind/Weather/Stress was also modeled on a 666yr return interval (p= 0.0015) causing a transition to A.

Disturbances

Fire Regime Group:** II

Historical Fire Size (acres)

Avg 0
Min 0
Max 0

Sources of Fire Regime Data

- [ ] Literature
- [ ] Local Data
- [x] Expert Estimate

Fire Intervals	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	14			0.07143	78
Mixed	100			0.01	11
Surface	100			0.01	11
All Fires	11			0.09143	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fir combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inver of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- [ ] Insects/Disease
- [x] Wind/Weather/Stress
- [x] Native Grazing
- [ ] Competition
- [ ] Other (optional 1)
- [ ] Other (optional 2)

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