LANDFIRE Biophysical Setting Model

Biophysical Setting 3910130 Western Great Plains Dry Bur 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** 4/25/2007

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Vegetation Type
Forest and Woodland

Map Zone
39

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

Dominant Species*
QUMA2
PRVI
TIAM
PRUNU

General Model Sources
☑ Literature
☑ Local Data
☑ Expert Estimate

Geographic Range

This system is found in MZs 31, 39 and 40. It's not that common but interspersed throughout each. Bur oak occurs throughout the eastern half of MZ31 in a range of suitable sites. It would occur in all of MZ31 ECOMAP subsections except for 332Cd, 331Fn, 331Fk, 331Fj and 331fb. Bur oak woodland systems are fairly common along the Missouri River bluffs and within the prairie pothole region (eastern SD) as well as along the Niobrara. It is found along the Niobrara River and tributaries (especially in northeast NE). In MZ39, it occurred in ECOMAP subsections 332Bd, Be, De, Dd, Df and Dg and 251Ba, Bb, Bd, Bf, Ga and Ha. In MZ40, it would have also occurred in ECOMAP subsection 251Aa and maybe others.

This system is found in the northern part of the Great Plains. Bur oak occurs in McKenzkie County, ND, principally the Blue Buttes and the northeast corner of the county in addition to the Killdeer Mtns. Bur oak woodlands/forests are found in the Pembina Hills of northeastern ND. The Turtle Mountain area also would have bur oak stands as would some areas in the south central portion of the state. In SD, stands will occur in the Badlands, and along natural fire breaks, as well as along river breaks, including the White and Missouri River Breaks (Dave Ode, pers comm) and within the rugged terrain of the Prairie Coteau in eastern SD and southwestern MN. In NE, the system is found in the Pine Ridge and along the Niobrara River and tributaries as well as in northeast NE along the Missouri River bluffs.

Biophysical Site Description

This system occurs on soils ranging from eolian sands, loess, coarse alluviual floodplain deposits and

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heavy, fine-textured valley soils, with dry to mesic moisture.

Moving westward in the zone, bur oak is increasingly restricted to favorable microsites, such as wooded draws, riparian areas and other sites receiving extra moisture. However, in drier sites, dwarfed individuals can exist at low densities, e.g. on upper canyon slopes.

Bur oak is well adapted to growth on moist, rich bottomlands with sufficient, but not excessive, amounts of water. It grows in areas receiving 15-40in annual precipitation but does best where maximum annual precipitation averages 30-40in (Tirmenstein 1988).

The species is unusually plastic, varying directly in tree size and density with increasing moisture and other favorable factors such as soil and landscape position. Mature trees can range from stunted shrubs of about one meter height to very large trees . Density can range from more than 100 stems/acre with closed canopy to more savanna like densities of a few/acre.

This system is found in upland areas throughout the northern part of the Western Great Plains. Soils are predominately dry to mesic.

Quercus macrocarpa/Prunus virginiana habitat type forms relatively extensive communities on backslopes of intermittent streams and drainageways. This habitat type was limited to glaciated areas. The Populus tremuloides/Quercus macrocarpa community type occupied erosive slopes. Once these areas become stabiliized, the Quercus macrocarpa/Prunus virginiana habitat type will probably result because Quercus macrocarpa reproduces in the understory. The Quercus macrocarpa/Corylus species habitat type is found in the Killdeer Mountains and adjacent areas. This habitat type is on gentle slopes and the soils are more leached than many of the other types. The Betula papyrifera Corylus cornuta community type occupies similar sites and is seral to Quercus macrocarpa/Corylus species habitat type (Girard et al. 1989)

Vegetation Description

Bur oak is the only hardwood tree species able to survive frequent fire in more arid part of the zone. In more mesic and other areas of lower fire frequency, other woody species can include American elm, green ash, common hackberry, black walnut, American Linden (basswood) and eastern hophornbeam (ironwood). Ground story vegetation is reduced with increasing canopy density. At low density, herbaceous vegetation may be nearly identical with surrounding prairies. At higher densities cool-season herbs become more dominate, including wild ryes and bluegrasses.

Associated shrubs can include plums, currents, grape, chokecherry, rhus species and poison ivy.

This system is typified by the predominance of Quercus macrocarpa constituting at least 10% of the vegetation cover in any given example of this system. Other species, such as Tilia americana, Juniperus virginiana and Fraxinus spp., may be also present. Understory vegetation can range from sparsely vegetated to more dense and usually exemplifies the surrounding prairie grassland vegetation (NatureServe 2006).

Bur oak is the indicator species. In MZ31, other tree species would have been mostly absent under historical conditions. Shrubs named are merely grassland species that would co-occur.

Disturbance Description

This system is primarily driven by fire. Bur oak sprouts vigorously after fire or other disturbance. It sprouts prolifically from the root crown when the main stem is damaged; however, stump sprouting has

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also been well documented (Tirmenstein 1988). Bur oak bark is thick and fire resistant. Larger trees often survive fire (Tirmenstein 1988).

Without fire, seedlings of bur oak are unable to compete with other, more shade-tolerant species (Tirmenstein 1988). Bur oak could grow to a large size after fire because of its competitive advantage.

In the northern Black Hills, there is a separate bur oak type with a long MFRI.

In some of the woody draws, there is bur oak. Since it is fire-tolerant, a strong sprouter and shade intolerant, bur oak will be enhanced by stand replacing fire in times with higher moisture.

Fraxinus pennsylvanica is even more fire tolerant than bur oak - so it would sprout up too after high intensity fire. Periods with more fires - bur oak dominates. Without fire - elm and ash dominate.

There were frequent low-severity fires (or mixed severity as modeled). Less frequent stand replacement fires were generally associated with periods of exceptionally high moisture conditions immediately followed by severe dry conditions.

Such woodlands do not react as a fuel complex due to their lower density and substantial fire resistance. When fire occurs and affects, it happens on the individual tree level, not the stand level.

Adjacency or Identification Concerns

In the eastern portion of the zone, other trees species may outnumber bur oaks. These drop out moving westward. Thus, setting exact system boundaries may be subjective.

This BpS grades into more diverse woodlands eastward. The increase of fire-intolerant species such as ash and hackberry would give the appearance of a denser, more diverse woodland than the historical setting.

This bur oak system is confined to microsites but would grade into adjacent prairie types or in the east to denser, more diverse hardwood woodlands.

Stands of bur oak can also be included within Central Mixedgrass Prairie (CES303.659); however, that system would only include small patches or single trees protected from fire. Any stands of bur oak or more substantial woodlands should be included within this system.

Similar systems include hardwood draws throughout this system's range. In the eastern portion (subsection 251B) of these mapzones (MZs 31 and 39), stands of this system can become more diverse and similar to North-Central Interior Dry-Mesic Oak Forest and Woodland or North-Central Interior Oak Savanna.

Fire suppression within this system can lead to more closed canopies including more fire-intolerant species such as green ash and hackberry and a decrease in the cover of herbaceous grass species in the understory. Grazing, conversion to agriculture, and past timber harvesting can impact this system. Overgrazing can also lead to a decrease in understory species, and timber harvesting can completely eliminate examples of this system.

This system today is probably denser where not cut. Typically when you burn through this for the first time after decades of fire suppression, there is considerable mortality of mature oaks due to ignition of dead, decadent material that would have burned less intensely with more frequent surface fires. Currently,

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fire is absent from the system, so when it does burn, it tends burn all at once.

Bur oak communities may be replaced by oak-basswood or more shade-tolerant oaks (white and red) in the absence of fire in eastern SD.

Typically, the system also is heavily affected currently by cattle grazing which nearly eliminates reproduction, reduces shrub understory, alters herbaceous community to exotic cool-season grasses, bluegrass, smooth brome. Further, stands include fire-intolerant invading sppecies such as ash and hackberry. In the worst cases, it is completely engulfed by eastern redcedar thickets, with eventual loss of oaks expected due to shading.

The exotics or invasives are primarily in the understory. Siberian elm could also be a component in some localized sites. Eastern red cedar also functions as a weed in this system.

In the worst case, cedar forest can completely swallow the oaks which become invisible. Clearcutting cedar reveals dwarfed, dying oaks.

Native Uncharacteristic Conditions

Stands are likely more dense today than was the case historically.

Scale Description

This system is usually comprised of smaller patches (1-50ac) as confined by microsite conditions. However, fires were likely from the surrounding grassland systems… so they were part of a larger fire.

Issues/Problems

Comments

This system was created from scratch for MZ31. However, NatureServe ecological system description information and FEIS information was added by co-RL for MZs 31, 39 and 40. Some of the disturbance information about bur oak species from MZs 29 and 30 was also incorporated by co-RL for MZs 31, 39 and 40. Co-RL also made some quantitative changes to the model to better align with the description/model concept.

Vegetation Classes

Class A 19 %

Early Development 1 All Structure

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

QUMA2	Upper
ANGE	Lower
HESP11	Lower
CAREX	Lower

Structure Data (for upper layer lifeform)

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

☑ Upper layer lifeform differs from dominant lifeform.

Description

During this stage, trees are the tallest plants, but grasses remain dominant and not yet suppressed or altered in species composition by effects from seedling/sapling trees.

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New stands develop primarily when acorns are buried by rodents (fox squirrels) in short grassland near existing trees. Short-statured grasslands are required to allow access by squirrels, and probably to reduce fire frequency/severity during the more vulnerable seedling and sapling stages. This process probably is independent of eventual tree size and density. Class A can also result from stand replacing fire or severe weather events.

This class lasts for 20yrs and then succeeds to Class B.

Replacement fire was modeled to occur every 100yrs setting succession back to the beginning. (A reviewer questioned whether or not fires would be more frequent in this stage considering it's more of a grassland stage; however MFRI retained.)

Class B **17 %**

Late Development 1 All Structures

Indicator Species* and Canopy Position

QUMA2

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	41 %	80 %
Height	Tree 5.1m	Tree 25m
Tree Size Class	Very Large >33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Description

This stage can persist. This is a relatively stable state, independent of eventual tree size and density. This young stand of class B gets thinned by fire, drought, or storms to produce class C.

Mixed-severity fire (modeled every 30yrs) causes a transition to class C, late open. Surface, low severity fires occur in this class with, modeled with a probability of 0.05 (every 20yrs) and do not cause a transition.

Drought was modeled as option 1 occurring every 100yrs, bringing this stage to class C, the late open stage. Storms modeled as wind/weather stress occur also every 100yrs, causing a transition back to class A.

A reduction in fire frequency/severity for as little as 10yrs, due to a wet weather cycle, grazing understory vegetation, etc. will move to class D (modeled as Alternate Succession with a 0.1 probability).

Class C **35 %**

Late Development 1 Open

Indicator Species* and Canopy Position

QUMA2

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	11 %	40 %
Height	Tree 5.1m	Tree 25m
Tree Size Class	Very Large >33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Description

This stage can persist. This is a thinned, older stand. Movement to this lower density class from class B is due to unusual conditions of drought, storm, or fire severity. Lower density may persist for decades or longer when more stable conditions return. Stand differs from local starting class B condition in having fewer younger trees, and so a higher proportion of older, larger trees. This is due to thinning from class B. Older, larger trees can become decadent, suffer damage from drought, storms, etc. and accumulate. It's this stage

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that results.

Due to mixed severity fires from class B, stands in class C will be uneven aged, but predominately older, larger trees, because individuals are long-lived and only rare reproduction is required to maintain density. Also, bur oak resprouts vigorously from the root crown when topkilled by fire, storm, and sometimes by drought. Thus, the same individuals persist, although aerial portions may be of varying ages because of resprouting.

Class C still has big trees as in class B, but fewer of them.

Grazing was modeled to occur on a small proportion of this class each year (1% or every 100yrs), but not causing a transition.

Wind and tornadoes modeled as wind/weather stress were modeled to occur every 100yrs causing a transition back to class A.

Low severity fire would maintain this in class C by keeping seedlings from growing up and resulting in a high-density stand; it was modeled to occur every 25yrs keeping this class as class C. Mixed severity fire should top-kill enough trees to result in re-sprouting and a younger, denser status that should fit into class B; it was modeled to occur half as often as the low severity fire. This allows for a renewed bout of reproduction. Without fire, this class can revert to class D. This was modeled as alternate succession with a probability of 0.02.

Class D **29 %**

Late Development 1 Closed

Indicator Species* and Canopy Position

QUMA2

Structure Data (for upper layer lifeform)

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

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

☐ Upper layer lifeform differs from dominant lifeform.

Description

This stage can persist in the absence of disturbance. This is a closed stand in most favorable sites. Movement to higher density stands from the starting class B condition, due to favorable moisture cycles and reduced fire frequency/severity. Stand would have higher density than corresponding local class B, with higher proportion of younger and smaller trees.

A combination of fire and drought can prevent continued excess reproduction, restabilizing stand and returning it to class B or C.

Fire was modeled to occur every 15yrs, half the time mixed fire causing a transition to B, and have the time low severity, surface fire causing a transition to class C. Replacement fire occurs infrequently - every 200yrs.

Wind/weather stress (drought) was modeled as occurring very infrequently (.005 probability) bringing this stage back to class A.

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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

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	300			0.00333	6
Mixed	45			0.02222	38
Surface	30			0.03333	57
All Fires	17			0.05889	

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) Drought
- ☐ Other (optional 2)

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LANDFIRE Biophysical Setting Model

Biophysical Setting 3911320 Central Mixedgrass Prairie

☑ *This BPS is lumped with: 1488*

☐ *This BPS is split into multiple models: Don't map 1488. In west of MZs 31, 39 and 40, put 1488 occurrences into mixedgrass systems that are adjacent to it: 1132 or 1141.*

General Information

Contributors (also see the Comments field **Date** 4/22/2007

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Vegetation Type

Upland Grassland/Herbaceous

Map Zone

39

Model Zone

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

Dominant Species*

HECO26 KOMA
NAVI4 ANGE
PASM SCSC
CAFI BOCU

General Model Sources

☑ Literature
☑ Local Data
☑ Expert Estimate

Geographic Range

This mixedgrass prairie system ranges from SD into the Rolling Plains and the Edwards Plateau of TX. The loessal regions in west-central KS and central NE, the Red Hills region of south-central KS and northern OK are all located within this system (NatureServe 2007).

In MZs 31 and 39, Central Mixedgrass Prairie (CES303.659) occurs in southwestern 39 and northeastern 31, in ECOMAP subsections 332Cd and 332Ca (interspersed within sandhills), 332Cc, 332Cf and 332Ce (Nebraska Loess Hills region) and it is prevalent within Rosebud Sioux Tribe Reservation and Eastern portions of Pine Ridge Indian Reservation. It might also be found in portions of 332Ch, but that is questionable, since it is more sandhills in that area. It is also found along the western Missouri River corridor north to Pierre and then just blends into shortgrass prairie (ECOMAP subsections 332Da, 332Df, 331Fe, 331Fv). The Central Mixedgrass Prairie is going to encompass part of MZ39 from southern SD and south – throughout the Central and Southern Great Plains (whereas BpS 1141 Northwestern Mixedgrass Prairie is the Northern version for Northern Great Plains). East of the Missouri River the Mixed Grass Prairie extends into ECOMAP section 332D (sand plains in northern part of 332Dg, east of Bassett) in areas of drier, more shallow soils where it blends in with the Western edge of the Northern Tall Grass Prairie. It also extends North to Highmore on the East side of the Missouri River.
The Sandhills probably indicate the transition to Central versus Northern.

Biophysical Site Description

Elevations range from 1200-3000ft. Temperatures range between extremes of hot summers and cold winters that are typical of a continental climate. This system occurs in the 16-18in precipitation zone. In

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NE, ECOMAP section 332C, the rainfall is higher than this, approximately 20in or more east to west in subsections 332Cc, 332Cf and 332Ce. Most of the precipitation occurs during the growing season. Soils vary, but are generally mollisols. Soils in this BpS are formed from a diverse mixture of various sedimentary deposits. These soils range from clayey to loamy with sandy loams present in the western edge. Terrain consists of gently undulating hills to large expanses of flat open ground in central NE, this type occurs on loess soils with very rugged terrain.

Vegetation Description

This vegetation type is characterized by the dominance of grasses such as western wheatgrass and little bluestem on thin uplands. This system typically contains grass species such as Bouteloua curtipendula, Schizachyrium scoparium, Andropogon gerardii, Hesperostipa comata, Sporobolus heterolepis and Bouteloua gracilis, although the majority of the associations within the region are dominated by Pascopyrum smithii or Schizachyrium scoparium. Isolated patches of Quercus macrocarpa also can occur (NatureServe 2007).

This system includes elements from Western Great Plains Shortgrass (BOGR) and Western Great Plains Tallgrass systems (Andropogon spp), but these are probably just micro sites. Trees are limited to riparian areas and drainages which may be listed under a different BpS. Silver sage may be found in some floodplains. Other woody species include skunk brush sumac and snowberry, but these species are limited in abundance. Wild plum, buffaloberry and choke cherry are present in limited amounts throughout the area.

Disturbance Description

This area is strongly influenced by wet-dry cycles. Fire, grazing by large ungulates and small mammals such as prairie dogs, and soil disturbances (i.e. buffalo wallows and prairie dog towns) are the major disturbances in this vegetation type. During dry conditions, there would be more grazing near permanent sources of water. During favorable conditions, grazers would graze further from permanent water sources.

It would be difficult for prairie dogs to move into an area without some kind of mechanism to reduce the vegetation, which could be drought, grazing or a combination of any. Under higher precipitation periods and with light grazing, grass grows quickly, and prairie dogs and other native ungulates might not be able to keep the grass down. Heavy ungulate grazing could create the right conditions for the prairie dog stage. Under favorable conditions, the prairie dog towns could even shrink because the vegetation is growing so fast. During dry conditions, short stature vegetation coupled with grazing can create more of a prairie dog community. Dry conditions can also set the stage for fire, which might then homogenize the landscape. Then the regrowth areas would be nutritious and palatable for the grazers. In wet cycles, there is broader grazing, as grazers would venture from permanent sources of water (Jack Butler, USFS, pers comm.).

MZ39 and MZ40 modelers recognized a varied degree of grazing pre-European settlement due to bison migration and other ungulates. Heavy grazing would move the community back to earlier stages.

Local site heterogeneity occurs on an even smaller scale, such as with bison wallows – which could even create ephemeral wetlands and a mesic situation. Carcasses could even create heterogeneity. There is also patch grazing occurring, and repeated re-grazing, which is enhanced by urine deposition, and an increased chance of re-grazing. Patch grazing creates a mosaic. It is possible that fire could homogenize an area from the preceding patch mosaic (Jack Butler, USFS, pers comm.).

Historically, there were likely close interactions between fire and grazing since large ungulates (i.e.: bison) tend to be attracted to post-fire communities. Average fire intervals are estimated at five to 15yrs, with the

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average probably 8-10yrs. Lightning fires were most common in July and August, but probably occurred from about April to September. Seasonality of fires influences vegetation composition. Recurring early season fires (April - May) tend to favor warm-season species, while late season fires (August - September) may affect grass species relatively equally. Cool season grasses begin to cure in mid June, making fire more likely in late summer than earlier in the growing season. Fires historically could occur at any time of year, but most likely more common in late summer if dry and in early fall after frost and than again in early spring prior to green up.

Native American fires were prevalent in and around encampments for the purpose of driving animals and in some instances escaped cooking or warming fires.

Replacement fire in our model does remove 75% of the aboveground cover as assumed in the literature. However, MZ39 and MZ40 modelers did not think that loss of the aboveground cover by the replacement fire will necessarily induce retrogression back to an earlier seral stage because the main component of dominant grasses remains unharmed to insure the continuity of the seral stage. However, fire will significantly reduce cover for a season or two. Forb species are often more prevalent for the first few years as well.

Ortmann in his Rapid Assessment review, suggested that, in addition to fire, drought and grazing, insect outbreaks (Rocky Mountain locust) would have impacted all classes.

From instrumental weather records, droughts average about one in every 10yrs, but droughts are often semi-periodic lasting three to four years in 30-40yr cycles.

Adjacency or Identification Concerns

This system is bordered by the shortgrass prairie on its western edge and the tallgrass prairie to the east. In MZs 31 and 39 in some areas, this also transitions in the west to 1141 (Northwestern Mixedgrass Prairie). From SD to ND, there is also tallgrass. Tallgrass is from ECOMAP subsection 251Aa to the East.

This system is also found along the western Missouri River corridor north to Pierre and then just blends into shortgrass prairie. The shortgrass prairie is predominantly western wheatgrass, blue grama and buffalograss.

It is probably going to be difficult to distinguish Central Mixedgrass Prairie BpS 1132 from Northwestern Great Plains Mixedgrass Prairie BpS 1141. The distinction can probably be done based on soils and geography. Please see "Geographic" section above for information. Central Mixedgrass 1132 adheres to the Central and Southern Great Plains, whereas Northwestern Great Plains Mixedgrass 1141 adheres to Northern Great Plains. BpS 1141 excludes the sandhills and goes from northern NE and west to central MT and is bordered on the east by Central Mixedgrass 1132. BpS 1141 Northwestern version is probably defined by the Missouri River. See Geographical description for more information. However, BpS 1141 should transition to BpS 1132 which should transition to tallgrass prairie systems. The boundaries of this system are defined by soils and topography, and this system tends to transition gradually into other systems.

The distinction between BpS 1132 and 1141 might also be based on the shift between cool and warm season grasses. The difference between BpS 1132 and 1141 is the C3-C4 shift of cool to warm season grass species. In BpS 1141, there are more western – festucas, needle and thread, stronger cool season component than BpS 1132.

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There are some good examples of mixedgrass prairie still in the Dakotas. There are some well managed ranches and parks. There is enough public land – approximately three million acres of national grasslands as well as national parks which are in good condition. There are also some private lands in good condition. There are some shifts in species but perhaps just western wheatgrass and blue grama (Jack Butler, USFS, pers comm).

Current conditions in Loess Hills grassland system is degraded by chronic improper grazing with lots of C3 exotic grasses having replaced former C4 dominants.

Typical to this region is the encroachment of eastern red cedar. Many unmanaged landscapes are becoming totally dominated by red cedar. Differing tribal management practices can influence the degree of encroachment, particularly along the Missouri River. Many introduced species such as smooth brome, Kentucky bluegrass, Canada thistle and Japanese brome, are increasing. Sweet clover, biannual, can increase during wet springs. Massive encroachment of other introduced species i.e. leafy spurge and red cedar. Cheatgrass currently is increasing in portions of this system. Cheatgrass is a winter annual and decreases under spring prescribed fire.

Plowing is occurring currently.

Landscape burning was much more prevalent in the past than today by either Native American burning or unsuppressed free burning wildfire.

There might be more of the early successional, shortgrass class (A) on the landscape today, due to introduced species and grazing.

When thinking about similarity or departure from historic or uncharacteristic communities at landscape levels, the following situations might be useful to check mapping results against classification and model logic. The major influences on current vegetation composition and structure in the Great Plains are:

1) Conversion of grassland to cropland.

2) Introduced species, primarily crested wheatgrass, annual bromes, smooth brome etc. and sweetclover.

3) Shift from midgrass dominated grassland communities to shortgrass dominated communities through season long heavy grazing (departure from historic), if percentage is outside range of variability. Prairie dog towns would fit into this category. This dynamic can be a response to long-term periodic drought as well (departure from historic range). The midgrass to shortgrass change is a shift that has occurred historically in response to fluctuating climate (drought, above normal precip cycles), grazing intensity/recovery. More may be in shortgrass, under current intensive pastoral grazing systems vs. migratory grazing patterns that occurred historically. Grazing would shift midgrass communities to shortgrass dominated communities (Bison may or may not have influenced this, but season long heavy livestock grazing seems to cause this shift). So a high percentage of the landscape in shortgrass, versus midgrass would indicate a departure.

4) Shift from grassland communities to forest, wooded, or shrub dominated communities in absence of fire (departure or uncharacteristic for grass BpS). This may be a key shift that has occurred or is occurring on the great plains along with conversion of rangeland to cropland and planting of introduced grass species

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(CRP lands). Current CRP practices are native vegetation. Probably more meaningful in terms of fire disturbance relationships than the shortgrass-midgrass shift.

With the exception of areas occupied by prairie dog towns, the characteristic late succession communities should be dominated by midgrass dominated plant communities. Tall grass dominated communities would only occur as unmapped inclusions associated with topo-edaphic positions. Tall grass dominated communities include those dominated by prairie sandreed, big bluestem and Indian grass.

Native Uncharacteristic Conditions

Scale Description

Fires probably ranged in size from 10s to 10,000s of acres. The variation depends on build-up of fuels which were influenced by precipitation and grazing. Extent of weather influences (wet-dry cycles) would have been very widespread. In the loess canyon regions and other areas where terrain is rugged, such as along the Missouri River, topography would influence spread of fire.

Local site heterogeneity occurs on an even smaller scale, such as with bison wallows – which could even create ephemeral wetlands and a mesic situation. Carcasses could even create heterogeneity. There is also patch grazing creating a mosaic. It is possible that fire could homogenize an area from the preceding patch mosaic (Jack Butler, USFS, pers comm.).

Issues/Problems

The model created by MZs 31 and 39 modelers was based upon a composite 26yrs of range management and prescribed fire monitoring, on the following Indian Reservations: Lower Brule, Crow Creek, Rosebud, Pine Ridge, Yankton and land of the Ponca Tribe of NE.

Comments

This model for MZs 31 and 39 was adapted from the model from the same BpS 1132 from MZ30 created by Mitch Iverson, Amy Symstad and Travis Lipp and reviewed by Steve Cooper, Steve VanFossen and Eldon Rash. Model for MZs 31 and 39 changed significantly quantitatively. Co-RL for MZs 31 and 39 also made some model tweaks to more similarly match MZ30 model. Review also resulted in quantitative changes, but modelers were consulted to determine if they wanted to change modelership or not.

The model for BpS 1132 for MZs 29 and 30 was adapted from the RA model R4PRMGn Northern Mixed Grass Prairie, created by Cody Wienk and Lakhdar Benkobi and reviewed by David Engle and John Ortmann. Other modeler for MZ30 was Terry Chaplin. Other reviewer was Jim Von Loh. RL for MZ30 also provided input and changes to the model to a great extent. Approval from original modelers/reviewers sought.

Vegetation Classes

Class A **30 %**

Early Development 1 Open

Upper Layer Lifeform

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

Fuel Model 1

Indicator Species* and Canopy Position

ARFR4	Lower
BOGR2	Upper
PASM	Upper
BUDA	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	40 %
Height	Herb 0m	Herb 0.5m
Tree Size Class		

- [ ] Upper layer lifeform differs from dominant lifeform.

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Description

This is the immediate-post-disturbance-post-fire stage or the very short-stature vegetation resulting from disturbance or heavy ungulate grazing. The fuels in this class are generally too sparse and/or too short to carry fire.

A variety of forb species such as scarlet globemallow and curlycup gumweed cab are common in this class, and grasses can also be common. This class will have species that are grazing resistant and low growing and drought-tolerant.

Common grass species include blue grama, buffalograss, western wheatgrass and prairie junegrass. Fringed sagebrush can also be a component of this class. Prickly pear, man sage (ARLU), fringed sage and broom snakeweed occur in this class. Abundance of prickly pear is much higher than in other seral stages. Other species are SPCO and ARPU9.

This class was initially set to succeed to class B between three and seven years. However, reviewers questioned the low range of three years. It would succeed in three years only under favorable conditions – unless the site is occupied by prairie dogs, and then it would remain as a prairie dog stage. It would increase in size during drought and grazing and then it would decrease during a wet cycle. It's a shifting mosaic of prairie dog movement and towns dependent on grazing and wet/dry cycles. If in a prairie dog state, then the class would last longer in order to transition out of it; however, this is accounted for, by having a prairie dog disturbance in the model, resetting succession and keeping it in this class. This class was therefore set to succeed to B after six years, as per reviewer comments.

Prairie dogs probably occupied between 15-40% of an area during some time. Class A should probably have between this amount, since class A includes both the prairie dogs and post-disturbance areas. Amount in this class would also vary by distance to permanent sources of water. During dry conditions, there would be more grazing near permanent sources of water. During favorable conditions, grazers would graze further from permanent water sources. However, it would be difficult for prairie dogs to move into an area without some kind of mechanism to reduce the vegetation, which could be drought, grazing or a combination of any. (Jack Butler, USFS, pers comm.).

Data from prairie dog towns (early seral, aka class A) suggest cover ranges from 0-80%. Height is most valuable measure of difference between early and other seral stages, but height in mixedgrass prairie often is not much greater than 50cm -- resolution of mapping may not be great enough to distinguish among classes.

High, prolonged heavy grazing was modeled as Optional 1. This occurs on 20% of this class each year, keeping it in this class. This includes prairie dog impact.

Drought combined with grazing was modeled as Optional 2. This occurs on 1.2% (.012 probability - every 80yrs) of this class each year. Drought alone was modeled as wind/weather stress occurring every 25yrs but not setting it back to the beginning of the stage.

Regular grazing occurs on 60% of class each year.

Replacement fire occurs every 5-10yrs. However, reviewer questioned this interval, as this class and fire is driven more by wet/dry cycles. Most of class A couldn't carry a fire if heavy grazing and drought are occurring as well as prairie dogs. Therefore, this was changed to occur every 25yrs. Fire also doesn't set this

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stage all the way back to the beginning, considering the grasses would quickly resprout. It would take fire, grazing, drought to set it all the way back to the beginning.

Drought conditions could force this stage back to bare ground and annuals. Historically, however, there was very little of the component of annuals and shrubs.

Class B **65 %**

Mid Development 1 Open

Upper Layer Lifeform

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

Fuel Model 3

Indicator Species* and Canopy Position

BOGR2	Mid-Upper
PASM	Upper
CAFI	Middle
SCSC	Middle

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	41 %	100 %
Height	Herb 0m	Herb 1.0m
Tree Size Class		

☐ Upper layer lifeform differs from dominant lifeform.

Description

Blue grama, western wheatgrass, needlegrasses, prairie junegrass, upland sedges and little bluestem are common grasses. In some areas species such as big bluestem and prairie sandreed are locally common. Western wheatgrass and little bluestem are the most common species as this class ages. In some areas, western wheatgrass forms dense stands.

Common forbs include scurfpea, prairie coneflower, Rocky Mountain beeplant, scarlet globemallow and dotted gayfeather. Prickly pear, man sage (Artemisia ludoviciana), fringed sage, snowberry and broom snakeweed occur in this class. Also, Agropyron smithii is present.

Cover in this class would actually range from 40-80%, depending on soils and weather for the year and the addition of the third class to account for abnormally long periods of low fire activity.

Native grazing occurs on approximately 20% of the class each year, maintaining this stage. High, prolonged heavy grazing was modeled as Optional 1. This occurs on approximately 25% of this class each year.

Replacement fire occurs approximately every ten years. It was modeled as occurring every 10yrs, most of the time not causing a transition back to the beginning, but some of the time causing a transition back to A. After fire, there is probably also heavy grazing.

Drought can also occur, but infrequently causing a transition back to class A. Regular drought could occur and not cause a transition (not modeled).

With lack of fire, encroachment might occur after this class. Trees (juniper, chokecherry) and shrubs might appear with higher cover. This class was therefore modeled as succeeding within itself but having an alternate successional pathway going to C with a probability of 0.01.

It would be uncharacteristic to have higher than 20% cover of shrubs/trees.

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Class C 5 %

Late Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☑ Shrub
- ☐ Tree

Fuel Model 2

Indicator Species* and Canopy Position

PRVI	Mid-Upper
SYOC	Lower
JUVI	Upper
PASM	Lower

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	11 %	60 %
Height	Shrub 0.6m	Shrub >3.1m
Tree Size Class		

☑ Upper layer lifeform differs from dominant lifeform.

Grasses encompass open areas between stands of cedar.

Description

The transition to class C would occur due to lack of fire over an extended period of time. This shrubby stage might occur more on the eastern end of the mapzones or in areas that are more protected from fire such as ravines in the deep loess regions.

Shrubs and other climax species would dominate with an understory of fine fuels within the unburned area. Any areas within this class that do burn would return to class A conditions.

Grazing occurs that would cause a transition back to B on 2% of the class each year.

Replacement fire occurs approximately every 10yrs.

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:** II

Historical Fire Size (acres)

Avg 10000
Min 10
Max 100000

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	8	2	30	0.125	100
Mixed					
Surface					
All Fires	8			0.12502	

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
- [x] Other (optional 1) heavy prolonged grazing
- [x] Other (optional 2) drought + grazing

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LANDFIRE Biophysical Setting Model

Biophysical Setting 3911410 Northwestern Great Plains Mixedgrass Prairie

☑ *This BPS is lumped with: 1085, 1488*

☐ *This BPS is split into multiple models:* *This BpS is lumped with 1085, 1488. 1085 may be grouped into 1141 considering that the shrub species that may grow west of the Missouri River in ND and SD (Wyoming big sagebrush, silver sagebrush, rabbit brush, fringed sagewort, western snowberry, etc.) obtain less than five percent cover.*

There is a lot of western snowberry today, but there shouldn't have been historically. In the mixedgrass prairie, uplands are now covered with snowberry, and that probably did not exist historically. Mesic shrubs (snowberry, chokecherry, buffaloberry etc.) did occur historically, but maybe more as inclusions within the mixedgrass prairie on more mesic sites (swales, draws, drainageways, north aspect slopes, etc.). It appears they are increasing on the landscape in absence of fire, migrating/expanding from their historic locations into adjacent uplands, especially snowberry. As combined with 1141 mixedgrass prairie, if there is more than 10% cover on over five percent of the landscape, it is probably uncharacteristic (Jeff DiBenedetto, USFS, pers comm.).

Don't map 1488. In west of MZs 31, 39 and 40, put 1488 occurrences into mixedgrass systems that are adjacent to it: 1132 or 1141.

General Information

Contributors (also see the Comments field **Date** 6/11/2007

Modeler 1	Co-RL Elena Contreras	econtreras@tnc.org	**Reviewer**	Jack Butler rvwd concept	jackbutler@fs.fed.us
Modeler 2			**Reviewer**	Jeff DiBenedetto	jdibenedetto@fs.fed.us
Modeler 3			**Reviewer**	Cody Wienk	cody_wienk@nps.gov

Vegetation Type

Upland Grassland/Herbaceous

Map Zone

39

Model Zone

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

Dominant Species*

PSSP6	SCSC
NAVI4	KOMA
PASM	ANGE
HECOC8	BOGR2

General Model Sources

☑ Literature
☐ Local Data
☑ Expert Estimate

Geographic Range

This system covers northern NE into southern Canada , and through the Dakotas between the northern tallgrass prairie and the Rockies (Samson and Knopf 1998).

This system extends from northern NE into southern Canada, and west to central MT. The U.S. range corresponds to Bailey et al. (1994) sections 331D, 331E, 331F (mostly), 331G, 332A, 332B, and perhaps

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minor extensions into 251B, and in Canada to the Moist Mixed Grassland and Fescue Grassland (NatureServe 2007).

This system's extent also coincides with EPA Ecoregions Level III and IV, 42-Northern Glaciated Plains, 43n-Montana Central Grasslands, 43m-Judith Basin Grasslands, 43o-Montana Unglaciated high Plains, and 43a-Missouri High Plateau (Woods et al 2002).

This system occurs in the western portion of MZs 39 and 40 and the north and northwest portions of MZ31.

Mixedgrass prairie is the dominant vegetation type in the Northern Great Plains Steppe Ecoregion.

Biophysical Site Description

The elevations range from 1900-4000ft, or up to 6500ft in MZ29. The continental climate entails long cold winters, hot summers with low humidity and strong winds between November through April.

Mean annual precipitation is generally 10-25in, with the higher precipitation falling in the eastern portions especially adjacent to the northern tallgrass prairie areas. In northern areas such as ND that receive significant snowfall, snowmelt provides significant amounts of moisture to the landscape (i.e. many of the pothole wetlands embedded in the landscape are wet in the spring because of this snow melt). The western part of this BpS is characterized by C3-cool-season plants and the eastern part of the BpS has an increase in abundance of C4-warm season plants, almost to the point of dominance in the plant community. (Although as it transitions to the warm season plants, BpS 1132 should be considered.)

This system occurs ubiquitously across soil types, except alkaline flats. Kinds, amounts, and proportions of plants vary widely relative to soil texture, soil depth, percent slope, and aspect. Bunchgrass communities dominate on shallow soils. Mid, short, and bunchgrass communities comprise the remainder.

The landscape is undulating rolling, and as you move west to east becomes more level as you reach the Red River Valley and northern tallgrass prairie area.

Vegetation Description

According to Samson et al (1998), the mixedgrass prairie in the Drift Prairie Region in ND and SD is a wheatgrass-blue stem-needlegrass complex, while the Missouri Coteau region in these two states is known as the wheatgrass-blue grama-buffalo grass mixture.

The number of plant species found in the mixedgrass prairies exceeds that in other prairie types because of ecotonal mixing between the tallgrass and mixedgrass regions (Samson et al 1998).

This system contains >50% cover of natural, cool-season grasses such as Festuca spp., Pascopyrum smithii, Elymus lanceolatus, Hesperostipa comata, Hesperostipa curtiseta and Nassella viridula (NatureServe 2007).

The vegetation is dominated by cool and warm season perennial grasses including needle grasses (i.e.green needle, porcupine, needle and thread, etc) and wheatgrasses (i.e. western wheatgrass, slender wheatgrass, bearded wheatgrass). This northern mixedgrass area is typified by more C3 plants than the more southern regions of the mixedgrass (BpS 1132). Further east nearing the tallgrass prairie, warm season grasses such as big blue stem, little blue stem, side-oats grama, etc are more prevalent. Hesperostipa spartea could also be a dominant or indicator.

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The timing of precipitation and precipitation flushes that occur in mid-June through mid-July, going from west to east geographically, result in warm season grasses that are more prominent versus cool season grasses as transitioning to east, through the precipitation gradient. As one goes further east and north, MT and ND have a more typic ustic moisture regime, frigid temperature regimes. As one proceeds further west, more aridic ustic frigid. SD is more typic ustic, and it gets mesic as one goes further south (WY, south SD) due to latitudinal gradients and elevational changes.

Shrubs and halfshrubs (Wyoming big sagebrush, silver sagebrush, rabbitbrush, fringed sagewort, western snowberry, etc.) obtain less than five percent cover. Most of the ground surface is covered and bare ground is less than 10% on more mesic sites and 20% on more xeric sites (e.g. glacial till, clay and soils).

The most common shrub is silver sagebrush, which resprouts after fire. Currently, with the absence of fire and occasional overgrazing, silver sagebrush has locally invaded upland sites and increased.

A diverse array of perennial summer forbs (black samson, scurfpea, prairieclovers, flax, dotted gayfeather,scarlet globemallow, etc.) occupies 10% of the community.

In pre-European conditions, there was a component of this BpS that had significant prairie dog impact and was characterized by broom snakeweed, prairie sagewort, sixweeks fescue and plains pricklypear.

Current conditions are different - please see Identification Concerns or Issues/Problems boxes.

Disturbance Description

Periodic grazing and replacement fire, when it occurred in an intact community, resulted in removal of most of the above-ground biomass, but resulted in little mortality and relatively rapid recovery times.

Disturbance varied widely in size. Fires ranged from local (tens of acres) to landscape level (thousands of acres). 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.) or a weather event (precipitation, wind direction change, humidity change, etc.). Growing season (mid May to mid Aug) 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. Mosaic fires were probably a result of patchy disturbed areas, topography, geography, hydrology and climate.

Fire and grazing were the dominant disturbances in this type. With estimates of 30-60 million bison in the Northern Great Plains (Isenberg 2000), herbivory by large mammals was also a significant disturbance to the grasslands. Large mammals preferentially grazed recently burned sites.

Bison were not the only major ungulate on the plains. Referencing Lewis and Clark journals, they observed large numbers of elk and antelope as well. The grazing patterns of these animals probably also influenced the frequency, extent and pattern of fire on the great plains. Reducing fuels where they grazed and affecting fire spread etc. These areas of grazing influence probably shifted seasonally and annually as a function of herd migration patterns.

Fire and grazing disturbances would have similar effects in temporary and seasonal wetlands, as well as in the wet meadow zone of the semi-permanent wetlands. Ponded wetlands would add to the patchy/mosaic

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nature of the fire effects over the landscape. Pothole hydrology is highly influenced by annual and long term climatic gradients - wet and drought cycles have persisted through history.

Fuel load recovery times are an alternative means by which to estimate the minimum average return interval for grassland fires, though this approach has not been formally attempted. A general decrease in productivity of ungrazed northern mixedgrass prairie is reported for 1-3yrs post-burn, and litter loads may take 11-16yrs to completely recover (as per various studies) (Henderson 2005). The total standing crop of fuel, combining both current year production and litter, is capable of recovering to pre-burn conditions in 4-8yrs (Shay et al. 2001). Theoretically, for repeated fires to occur without altering long-term grassland productivity and species composition, the mean return interval should be eight years or greater (Henderson 2005).

Historically, the fire return interval averaged 8-12yrs for the region, but naturally occurring fuel breaks on slopes and badlands probably lengthened the mean interval. Fire-scarred tree-rings from areas within and adjacent to the northern Great Plains provide intervals within the 0-35yr range over the past 500yrs (Henderson 2005). Given a minimum return interval of 0.5yrs, mode of eight years, and 95% probability of a fire occurring within 35yrs, the resulting right-skewed distribution makes possible return intervals >35yrs but probably never longer than 100yrs (Henderson 2005).

A negative exponential distribution probably best describes the historic fire size distribution, with a large number <1ha, median 10-100ha, mean 1000-10,000ha and a low frequency of 50,000-1,000,000ha (Henderson 2005).

This area is strongly influenced by wet-dry cycles. Fire, grazing by large ungulates and small mammals such as prairie dogs and soil disturbances (i.e. buffalo wallows and prairie dog towns) are the major disturbances in this vegetation type. Areas that receive more precipitation are more likely to have tallgrass return. During dry conditions, there would be more grazing near permanent sources of water. During favorable conditions, grazers would graze further from permanent water sources.

Grazing and prairie dog towns also reduced fuel loads, fire frequency, size and intensity with the most substantial impacts in valley bottom shrublands and grasslands and upland grasslands near water. Historically, the majority of human caused ignitions were concentrated in spring and fall seasons, while lightning-caused fires were concentrated in late summer.

The prairie dogs towns would have shifted slightly over long periods of time – becoming more flammable when the dogs move away (or periodically decrease). At their largest expansion periods, prairie dogs would have occupied up to 80% of their potential habitat. So, this would have had, periodically, a huge effect on ungulate grazing, fire and, probably, soil hydrology changes as they change with litter and dominant species (Mary Lata, USFS, pers comm).

The absence of grazing and replacement fire for many years (e.g. 50yrs) would lead to an increased shrub component (snowberry and green ash) in precipitation zones greater than 14in, and a buildup of dead grass. (Buildups of litter generally result in decreased diversity and lower basal area of remaining grass plants.) Within 10-14in precipitation zones, Wyoming big sagebrush and silver sagebrush may also increase. Productivity of the grasses is decreased, resulting in greater mortality from smoldering fire.

Mormon crickets, grasshoppers and great plains locust might have had more of an impact in this system than currently defined, but unsure of historic impact and frequency (Jon Siddoway, NRCS, pers comm).

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Drought also occurs somewhat frequently. Some modelers felt it occurred every 30yrs, and some believed it occurred every five years. Short term precipitation variability may also influence species productivity. Drought periodicities centering around 58yrs were characteristic of southeast MT and eastern WY for the last ~300yrs. A 22yr rhythm was characteristic of 1892 to 1977, but less clear for 1801 – 1889 and did not occur in 1714 – 1801. Ten or more years without drought in any of the four areas occurred once or twice per century (Stockton and Meko 1983). A Northern Great Plains HRV draft study by Judy von Ahlefeldt states that the frequency of droughts was greater than five years in length for 2-300yrs (Weakley 1943).

There would be a difference between BpS 1141 Northwestern Great Plains Mixedgrass Prairie and BpS 1132 Central Mixedgrass Prairie in terms of species response/plant functional group response (cool vs warm season) to grazing. Warm season grasses are decreasers during grazing, but the same species in the Northern version are increasers – i.e.: little bluestem. The cool season grasses/groups are better forage for grazers in the north with burning, because they are increasing. The cool season grasses initiate growth first. These are differences at a very small scale though. Overall, the intervals for BpS 1141 and 1132 are probably very similar.

Adjacency or Identification Concerns

Northwestern Mixedgrass Prairie BpS 1141 transitions into BpS 1132 Central Mixedgrass Prairie, which transitions to Tallgrass Prairie.

It is probably going to be difficult to distinguish Central Mixedgrass Prairie BpS 1132 from Northwestern Great Plains Mixedgrass Prairie BpS 1141. The distinction can probably be done based on soils and geography. See Geographical sections in both models for information too. Central Mixedgrass 1132 adheres to the Central and Southern Great Plains, whereas Northwestern Great Plains Mixedgrass 1141 adheres to Northern Great Plains. BpS 1141 probably excludes the sandhills and goes from northern NE and west to central MT and is bordered on the east by Central Mixedgrass 1132. BpS 1141 Northwestern version is probably defined by the Missouri River. See Geographical description for more information. However, BpS 1141 should transition to BpS 1132 which should transition to tallgrass prairie systems. The boundaries of this system are defined by soils and topography, and this system tends to transition gradually into other systems. Precipitation zone is another indicator, as there seems to be an east – west change in precipitation going from low (west) to higher (east).

The distinction between BpS 1132 and 1141 might also be based on the shift between cool and warm season grasses. The difference between BpS 1132 and 1141 is the C3-C4 shift of cool to warm season grass species. In BpS 1141, there are more western – festucas, needle and thread, stronger cool season component than BpS 1132.

The central mixedgrass prairie is not well defined but in general is a transition area between the tallgrass prairie and mixedgrass prairie. There is higher precipitation and taller grasses than in 1141. There are more shrubby species. 1141 is further west and has ARTR2, whereas 1132 has more chokecherry/sumac.

Main difference is 1132 has higher moisture regime, more tallgrass plants, and lack of fire results in more shrubs and trees. Productivity might be lower in 1141 - soils generally not quite as deep, less rain, probably less litter build up as well, although the higher moisture in 1132 would allow litter to decompose at a faster rate (Mary Lata, USFS, pers comm).

BpS 1141 wouldn't function differently than 1132, and it wouldn't key out differently (Steve Cooper, pers

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comm). The only way you might be able to tell this apart is by geography. 1141 is further west.

Estimated declines in the mixedgrass prairie range from 68.3% in ND and 70% in SD (Samson et al. 1998). However, there are some good examples of mixedgrass prairie still in the Dakotas. There are some well managed ranches and parks. There is enough public land – approximately three million acres of national grasslands as well as national parks which are in good condition. There are also some private lands in good condition. There are some shifts in species but perhaps just western wheatgrass and blue grama (Jack Butler, USFS, pers comm).

Portions of the Northwestern mixedgrass prairie have been converted to agricultural production, urbanization, or have been overgrazed by domestic grazers. In the more eastern portions of this area, the landscape is cropland-dominated with remnant grasslands occurring in patchy islands throughout (i.e. the Drift Prairie). The more western portions of the system often lack management regimes that sustained the wetland in pristine times.

Prairie remnants are heavily invaded with woody vegetation and invasive species such as smooth brome in some areas, Kentucky bluegrass in small areas, and noxious weeds such as Canada thistle, leafy spurge, plumeless thistle, bull thistle, etc. Wetlands are often dominated by monotypic stands of reed canary grass or narrow-leaf and/or hybrid cattail. Other invasive species of concern include spotted, diffuse and Russian knapweeds, often along roads and stream corridors; leafy spurge and Canadian thistle, along stream corridors; yellow sweetclover; dalmation toadflax; and annual bromes, including Japanese brome. Dense clubmoss stands are also a problem in this class, as is blue grama - limiting productivity and diversity in this system.

Grassland areas that are heavily invaded with smooth brome or Kentucky bluegrass may appear similar to native sod areas simply because of grass presence, regardless of species composition or structure. Crested wheatgrass is also a non-native grass which has been seeded extensively in the plains.

Areas with similar soils but steeper topography (>15%) are less productive and have a higher dominance of shrubs.

The natural grazing regime has been replaced with domestic livestock grazing that is targeted toward "moderate" grazing intensity. This is often characterized by grazing each year with removal of herbage over an extended period of the growing season without adequate rest and recovery from grazing. This is contrasted with the expected historic shorter, episodic grazing patterns. One result is more structural homogeneity. Under this grazing regime, taller, palatable grasses such as green needlegrass, bluebunch wheatgrass decrease, and short grasses such as blue grama and sandberg bluegrass increase, and western wheatgrass and needle and thread grass act as midgrass decreasors. Also under this grazing regime, litter may increase (depending on precipitation and instensity of grazing) with the expected results of decreased diversity and decreased vigor of remaining grasses. Only under season long grazing will warm-season grasses like little bluestem decrease. Season of use and/or twice-over grazing will impact the prevalence of little bluestem and other C4 plants.

Long-term high intensity grazing by domestic livestock without periods of rest and recovery can result in a conversion in the vegetation states from a midgrass dominated community to shortgrass dominated communities (blue grama, sedges, and sanders bluegrass, buffalograss in southern portions, junegrass). This should be distinguished from the s-class (class B) that's influenced more by presence of prairie dog towns - which have a higher forb component with less of a midgrass component than the other classes. In

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species composition, the prairie dog versus domestic grazed communities, are very different.

In current conditions, there has also been an increase in the amount of woody vegetation on the plains, particularly increases in snowberry on mesic sites and expansion of ponderosa pine into grasslands and shrublands which were probably maintained in a grassland state under historic fire frequencies. The lack of fire has shifted grassland systems to shrublands or woodlands.

The expansion of ponderosa pine and shrubs, including snowberry, yucca, prickly pear is noticeable, but more so (at least for these species) in the eastern portion of MZ29/30 and into MZs 39 and 40. There is also an increase of snowberry in draws, swales and upland depressions and expansion to adjacent upland settings.

Shrubs such as sagebrush and other shrubs (Wyoming sagebrush, silver sagebrush, western snowberry, rabbitbrush and fringed sagewort) increase greatly over the historic plant community. Silver sagebrush being a sprouter probably did occupy sites historically and now might have increased in density, but not aerial extent. It is however a shrub dominant on river and stream terraces (Wooded Draw and Ravine BpS or Flooplains BpS), where its seen today. Wyoming sagebrush where it occurs on the plains, is generally widely space low density stands which probably functioned similarly to big sagebrush to the west.

Compare the ecological site description to avoid using a shrub model for historic plant community when considering a grass site that has changed as a result of uncharacteristic grazing or unnaturally long fire return intervals. Unnaturally long intervals without fire may contribute to an increased shrub component (shrubs might include Opuntia spp and Yucca spp in NE). Xeric sites will experience an increase in sagebrush, whereas western snowberry will increase in mesic areas.

With the absence of fire and occasional overgrazing, silver sagebrush has, locally, invaded upland sites - at least that's how the range people interpret it. It’s questionable as to how extensive silver sagebrush was historically; however the fact that sage grouse were historically collected all the way east to the Missouri River causes question about the previous extent of sagebrush (Dave Ode, pers comm.).

There might be places, as there are further south and east of MZs 29 and 30, that now have crested wheatgrass as a major component, as it was heavily seeded in the 1930's (Mary Lata, USFS, pers comm). Major seeding of crested wheatgrass occurred up through the 1950’s with sporadic seeding occurring recently, particularly on CRP lands.

There is more woody species invasion further east. At 20in precipitation, deciduous trees come out and invade from the draws. If area not burned, will lose the prairie. In eastern ND and SD, there are trees there, that if they don't burn, they will cover up the prairie systems (but that's the tallgrass prairie, which is almost all agriculture now. Much of the mixedgrass prairie is converted to agriculture today). That wouldn't occur in the west as much. Trees would be restricted to the microclimate situation or in draws (Brian Martin, TNC, pers comm).

When thinking about similarity or departure from historic or uncharacteristic communities at landscape levels, the following situations might be useful to check mapping results against classification and model logic. The major influences on current vegetation composition and structure in the Great Plains are (Jeff diBenedetto, USFS, pers comm):
1) Conversion of grassland/shrublands to cropland (uncharacteristic types)

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2) Introduction of introduced species, primarily crested wheatgrass, annual bromes, smooth brome etc. and yellow sweetclover (uncharacteristic type)

3) Shift from midgrass dominated grassland communities to shortgrass dominated communities through season long heavy grazing (departure from historic, if percentage is outside range of variability. Prairie dog towns would fit into this category. This dynamic can be a response to longterm periodic drought as well (departure from historic range). The midgrass to shortgrass change is a shift that has occurred historically in response to fluctuating climate (drought, above normal precipitation cycles), grazing intensity/recovery. More may be in shortgrass, under current intensive pastoral grazing systems versus migratory grazing patterns that occurred historically. Grazing would shift midgrass communities to shortgrass dominated communities. (Bison may or may not have influenced this, but season long heavy livestock grazing seems to cause this shift.) So a high percentage of the landscape in shortgrass, versus midgrass would indicate a departure.

4) Shift from grassland communities to forest, wooded, or shrub dominated communities in absence of fire (departure or uncharacteristic for grass BpS). This may be a key shift that has occurred or is occurring on the Great Plains along with conversion of rangeland to cropland and planting of exotic grass species (CRP lands). This is probably more meaningful in terms of fire disturbance relationships than the shortgrass-midgrass shift.

With the exception of areas occupied by prairie dog towns, the characteristic late successional communities should be dominated by midgrass dominated plant communities. Tall grass dominated communities would only occur as unmapped inclusions associated with topo-edaphic positions. Tall grass dominated communities include those dominated by prairie sandreed, big bluestem and prairie cordgrass.

Native Uncharacteristic Conditions

With lack of fire, increased shrub or tree cover would be uncharacteristic and is occurring west of the Missouri River in ND and SD.

Scale Description

Disturbance varied widely in size. Fires ranged from local (tens of acres) to landscape level (thousands of acres). 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.) or a weather event (precipitation, wind direction change, humidity change, etc.). Growing season (mid May to mid Aug) 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. Mosaic fires were probably a result of patchy disturbed areas, topography, geography, hydrology and climate.

Bison herbivory occurred in a mob grazing or flash grazing method, with extensive herds migrating across the prairie as they graze.

Historically, natural grazing and fire generally encompassed hundreds to hundreds of thousands of acres. Repeated heavy animal impact such as prairie dog towns occurred at the scale of 10s -1000s of acres, as well as ungulate impacts from bison, elk, antelope and other ungulates. The grazing patterns of these animals probably also influenced the frequency, extent and pattern of fire on the Great Plains. Reducing fuels where they grazed and affecting fire spread etc. These areas of grazing influence probably shifted seasonally and annually as a function of herd migration patterns.

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A negative exponential distribution probably best describes the historic fire size distribution, with a large number <1ha, median 10-100ha, mean 1000-10,000ha, a low frequency of 50,000-1,000,000ha and rare outliers >1,000,000ha (Henderson 2005).

Issues/Problems

This BpS covers a large diverse area with relatively little extensive data or published studies for vegetation classification. Fire frequency is based primarily on inference based on understanding of the plant community dynamics and anecdotes or historical research (mostly oral histories) regarding Indian burning.

Again, it needs to be emphasized that the original MZs 31, 39 and 40 modelers were most proficient with the mixedgrass portions that are west of the Missouri River in ND and SD. They were recording from a knowledge base of the Drift Prairie and Missouri Coteau regions of ND and SD, which encompasses the transition zone from tallgrass to mixedgrass prairie as defined by Samson et al (1998). Therefore the results here were a best professional judgment based on our experiences working in ND, SD and MN.

Comments

This model for MZs 31, 39 and 40 was originally adapted by Cami Dixon, Sara Vacek and Shane DelGrosso from the draft model for BpS 1420 northern tallgrass prairie from MZs 39 and 40 created by Cami Dixon, Sara Vacek, Shane DelGrosso, Sandy Smart, Kyle Kelsey with little quantitative changes made. However, based on expert review for MZs 31, 39 and 40, the model was then changed by co-RL for all three zones, to better mimic BpS 1141 in MZs 29 and 30, which was intended to cover eastward as well, and to better mimic BpS 1132, the other mixedgrass model in MZs 31, 39 and 40 (instead of having model 1141 in MZ39 mimic tallgrass prairie).

BpS 1420 Adaption/Evolution: The model for BpS 1420 for MZs 39 and 40 was adapted from the Rapid Assessment model: R4PRTGn Northern Tallgrass Prairie created by Jim Drake jim_drake@natureserve.org and Jim Decoster jim_decoster@nps.gov and reviewed by Daryl Smith daryl.smith@uni.edu.

BpS 1141 Adaption/Evolution: BpS 1141 model for MZs 29, 20 and 30 was originally adapted from RA model R0PGRn created by Shannon Downey. Model for MZ20 was originally modeled with five boxes - by Shannon Downey and Steve Cooper. However, during a review session, reviewers (BJ Rhodes, John Carlson, Rich Adams and Bill Volk) suggested changes and changed this model to a three-box model. Agreement and input was received from the original modelers. Subsequent review of this model for an adjacent mapzone by modelers (Jeff DiBenedetto, Brian Martin, Cody Wienk, George Soehn and Bobby Baker) led to adoption of a different 3-box model. After agreement from original modelers and reviewers, this last three-box model is the one that was used for MZ20. Because the original five-box and other three-box models originally developed, were abandoned, the details and the changes are not detailed here. Subsequent to sclass review for MZ20, model for MZs 29 and 30 was changed based on mapping constraints to a two-box model. Therefore, model for MZs 29 and 30, is different than that for MZ20 in sclass proportions, age ranges, and cover/height and boxes. Other reviewers for MZs 29 and 30 were Shannon Downey, Jeff Jones, Steve Cooper and Mary Lata.

Other reviewers for BpS 1141 model for MZ20 were Steve Barrett, Mary Manning (USFS), Steve VanFossen (NRCS) and Jon Siddoway (NRCS).

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1132 Adaption/Evolution: This model for MZs 31 and 39 was adapted from the model from the same BpS from MZ30 created by Mitch Iverson, Amy Symstad and Travis Lipp and reviewed by Steve Cooper, Steve VanFossen and Eldon Rash. Model for MZs 31 and 39 changed significantly quantitatively. Co-RL for MZs 31 and 39 also made some model tweaks to more similarly match MZ30 model. Review also resulted in quantitative changes, but modelers were consulted to determine if they wanted to change modelership or not.

The model for BpS 1132 for MZ29/30 was adapted from the RA model R4PRMGn Northern Mixed Grass Prairie, created by Cody Wienk and Lakhdar Benkobi and reviewed by David Engle and John Ortmann. Other modeler for MZ30 was Terry Chaplin. Other reviewer was Jim Von Loh. RL for MZ30 also provided input and changes to the model to a great extent. Approval from original modelers/reviewers sought.

Vegetation Classes

Class A 25 %

Early Development 1 Open

Upper Layer Lifeform

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

Fuel Model 1

Indicator Species* and Canopy Position

	Upper
BOGR2	Upper
PASM	Upper
HECO26	Upper

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	40 %
Height	Herb 0m	Herb 1.0m
Tree Size Class		

- [ ] Upper layer lifeform differs from dominant lifeform.

Description

This represents the post-disturbance or post-fire stage community functioning under grazing and/or fire, dominated by cool and warm season rhizomatous perennial grasses, as well as bunchgrasses.

Dominant species are those common to the northern mixedgrass prairie such as Hesperostipa comata, Nasella viridula, Andropogon gerardii, Bouteloua gracilis, Koeleria macrantha, Pascopyrum smithii, Buchloe dactyloides and maybe Hesperostipa spartea. Other grasses are Schizachyrium scoparium, Calamovilfa longifolia and Pseudoroegneria spicata occur as dominant species in small patches. Other species in this class are Artemisia and western yarrow.

Due to the combination of the prairie dog stage (indicator species: BOGR2, POSE, ARFR, DYPA) and the early successional stage (indicator species: PASM, NAVI4, HECO26, BOGR2), the indicator species were combined for this class.

Forbs such as galium boreale are more abundant in the immediate post-fire vegetation. A variety of forb species such as scarlet globemallow and curlycup gumweed could also be common in this class. This class will have species that are grazing resistant and low growing and drought-tolerant.

Fringed sagebrush can also be a component of this class. Prickly pear, man sage (ARLU), and broom snakeweed occur in this class. Abundance of prickly pear is much higher than in other seral stages.

This might be a shortgrass EVT. A higher proportion of this class on the landscape today would indicate departure.

The fuel in this class is generally too sparse and/or too short to carry fire.

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This class lasts approximately three or more years. If in a prairie dog state, then the class would last longer in order to transition out of it; however, this is accounted for, by having a pdog disturbance in the model, resetting succession and keeping it in this class. The three-year interval attempts to capture what would happen post-fire or post-drought. (Also - post-heavy-grazing in current conditions would take longer to transition out of this class.)

The prairie dog stage would increase in size during drought and grazing and then it would decrease during a wet cycle. It's a shifting mosaic of prairie dog movement and towns dependent on grazing and wet/dry cycles. Prairie dogs probably occupied between 15-40% of an area during some time. Class A should probably have between this amount, since class A includes both the prairie dogs and post-disturbance areas. Amount in this class would also vary by distance to permanent sources of water. However, another camp feels that a prairie dog class should comprise approximately 5-8% of the landscape, and no more than 10% (Dan Uresk, pers comm). Research for historical NGP vegetation would have prairie dog communities within an early successional stage of max 10-15% across an entire landscape. So only a portion of the early successional stage would be a prairie-dog-type community - i.e.: maybe 5-8%.

Data from prairie dog towns (early seral, aka class A) suggest cover ranges from 0-80%. Height is the most valuable measure of difference between early and other seral stages, but height in mixedgrass prairie often is not much greater than 50cm -- resolution of mapping may not be great enough to distinguish among classes.

High, prolonged heavy grazing was modeled as Optional 1. This occurs on 20% of this class each year, keeping it in this class. This includes prairie dog impact.

Drought combined with grazing was modeled as Optional 2. This occurs on 1.2% (0.012 probability - every 80yrs) of this class each year. Drought alone was modeled as wind/weather stress occurring every 25yrs but not setting it back to the beginning of the stage.

Regular grazing occurs on 60% of class each year.

Most of class A couldn't carry a fire if heavy grazing and drought are occurring as well as prairie dogs. Therefore, replacement fire was modeled to occur every 25yrs. Fire also doesn't set this stage all the way back to the beginning, considering the grasses would quickly resprout. It would take fire, grazing, drought to set it all the way back to the beginning (not technically modeled). Drought conditions could force this stage back to bare ground and annuals. Historically, however, there was very little of the component of annuals and shrubs.

Because of LANDFIRE mapping rules, canopy cover is arbitrary number. These classes should actually be defined on the ground by biomass, litter, species.

Very little of A, B remain on the landscape today; most is C.

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Class B **70 %**

Mid Development 1 Open

Upper Layer Lifeform

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

Fuel Model 3

Indicator Species* and Canopy Position

PASM	Upper
NAVI4	Upper
HESP11	Upper
BOGR2	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	41 %	100 %
Height	Herb 0m	Herb 1.0m
Tree Size Class		

- [ ] Upper layer lifeform differs from dominant lifeform.

Description

Shrub species could be present with approximately 0-10% cover. Common shrubs - silver sagebrush, winterfat, fringe sagewort and rubber rabbitbrush. Skunkbush sumac would be less common, mostly on slopes and shallow soils.

Class B represents the intact historic plant community functioning under grazing and/or fire, dominated by taller, cool and warm season rhihzomatous perennial grasses, as well as bunchgrasses. This is the all-encompassing mid-late-development, functioning fine stage.

Mixedgrasses and forbs are dominant, woody vegetation (shrubs and trees) are widely scattered and limited to micro sites that escaped fire or to mature fire resistant trees. Both of these occur more commonly in the eastern parts of this Type.

Common species are Hesperostipa comata, Nasella viridula, Andropogon gerardii, Bouteloua gracilis spartea and Hesperostipa spartea. Schizachyrium scoparium, Calamovilfa longifolia and Pseudoroegneria spicata occur as dominant species in small patches. Other species in this class are Artemisia, grama grasses, western yarrow and prairie junegrass.

Forbs such as galium boreale are more abundant in the immediate post-fire vegetation.

Because of Landfire mapping rules, canopy cover is arbitrary number. These classes should actually be defined on the ground by biomass, litter, species. This class can be distinguished from A based on Fuel model (3 for B vs 1 for A) and biomass.

Replacement fire occurs every 10-15yrs. Replacement fire was modeled as occurring every 10yrs, most of the time not causing a transition back to the beginning, but some of the time causing a transition back to A. After fire, there is probably also heavy grazing. Little below-ground mortality occurs after replacement fire, and resprouting of perennial grasses and forbs often occurs within days or weeks, depending on season. Grasses show greater vigor; some forb establishment may occur as a result of exposure of mineral soil. Canopy cover recovers quickly after resprouting.

Native grazing occurs on approximately 20% of the class each year, maintaining this stage. High, prolonged heavy grazing was modeled as Optional 1, including prairie dogs. This occurs on approximately 25% of this class each year.

Drought can also occur, but infrequently causing a transition back to class A. Regular drought could occur and not cause a transition (not modeled).

The combination of drought and grazing (option 2) occurs infrequently bringing this class back to A.

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It has been suggested that grasshoppers and Mormon crickets might have a larger impact historically than the probability assigned here. However, unsure of impact and frequency.

With lack of fire, encroachment might occur after this class. Trees (juniper, chokecherry) and shrubs might appear with higher cover. This class was therefore modeled as succeeding within itself but having an alternate successional pathway going to C with a probability of 0.01.

It would be uncharacteristic to have higher than 20% cover of shrubs/trees. Shrub species could be present at 0-10% cover. Silver sagebrush and winterfat (on deeper soils) are the most common shrub, and would start resprouting. WY big sagebrush can also be a component (on shallower soils) of this BpS, although a small component.

Club moss might be present in Glaciated Plains at 0-5% cover,but not on shallow clay sites or dense clay sites, sands, saline upland, saline lowland, subirrigated, and wet meadow.

Class C **5 %**

Late Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☑ Shrub
- ☐ Tree

Fuel Model 3

Indicator Species* and Canopy Position

PRVI	Upper
SYOC	Upper
JUVI	Upper
PASM	Mid-Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	60 %
Height	Shrub 0m	Shrub >3.1m
Tree Size Class		

☐ Upper layer lifeform differs from dominant lifeform.

Grasses encompass open areas between stands of cedar. The grasses are still dominant, but shrub species are becoming more prominent on the landscape.

Description

The transition to class C would occur due to lack of fire over an extended period of time. This shrubby stage might occur more on the eastern end of the mapzones. Other species might include silverberry, quaking aspen (Populus tremuloides), willow (Salix spp.), cottonwoods, box elder, snowberry and prunus and can form dense thickets.

Shrubs and other climax species would dominate with an understory of fine fuel within the unburned area. Any areas within this class that do burn would return to class A conditions.

Grazing occurs that would cause a transition back to B on two percent of the class each year.

Replacement fire occurs approximately every 10yrs.

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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
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	8	2	40	0.125	100
Mixed					
Surface					
All Fires	8			0.12502	

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) heavy prolonged grazing including prairie dogs
- ☑ Wind/Weather/Stress
- ☐ Competition
- ☑ Other (optional 2) drought with grazing

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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 3911480 Western Great Plains Sand Prairie

☐ *This BPS is lumped with:*

☐ *This BPS is split into multiple models: Please see Adjacency/Identification Concerns box for areas and system types that might resemble this system but should be mapped as another system.*

General Information

Contributors (also see the Comments field **Date** 4/24/2007

Modeler 1	John Ortmann	jortmann@tnc.org	**Reviewer**	John Ortmann re-reviewed	jortmann@tnc.org
Modeler 2			**Reviewer**	Mary Lata	mlata@fs.fed.us
Modeler 3			**Reviewer**		

Vegetation Type

Upland Grassland/Herbaceous

Map Zone

39

Model Zone

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

Dominant Species*

ANHA BOHI2
CALO HECO26
SCSC SPCR
BOGR2

General Model Sources

☑ Literature
☐ Local Data
☑ Expert Estimate

Geographic Range

Nebraska Sandhills Prairie is found in central and western NE and south central SD covering approximately 5.5 million ha (Bleed and Flowerday, 1990).

For MZ31, this BpS is located in ECOMAP section 332 and Subsections 332Cd, 332Ca and 332Cb.

Biophysical Site Description

Within the last 10,000yrs, much of this area is thought to have shifted between active dune fields and more stabilized, grass-covered dunes depending on shifts in climate and changes to disturbance regimes. The area is dissected by several rivers, and includes wetlands, wet prairies and fens which increase in frequency from east to west. The Sandhills are the primary recharge area for the Ogallala aquifer maintaining one of the most consistent groundwater levels in the world. Soil types shift from sands in the west and on uplands, to sandy loams and loams further east and in floodplains. Soils in the Sandhills are generally often undeveloped and highly permeable. Blowouts and sand draws characterize some of the wind-driven disturbances of the region. When disturbed, the fragile nature of the soils can profoundly impact vegetation composition and succession within this system. On a coarse scale, the system may be divided into riparian, sands, choppy sands and dry valleys, each of which supports slightly different fire behavior and vegetation dynamics. Generally, dry valleys, sands and choppy sands may be combined for modeling purposes.

The distribution, species richness and productivity of plant species within the sand prairie ecological system are controlled primarily by environmental conditions, in particular the temporal and spatial distribution of soil moisture and topography.

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Soils in the sand prairies can be relatively undeveloped and are highly permeable. Soil texture and drainage along with a species' rooting morphology, photosynthetic physiology, and mechanisms to avoid transpiration loss are highly important in determining the composition and distribution of communities/associations within the sand prairies. Another important aspect of soils in the sand prairies is their susceptibility to wind erosion. Blowouts and sand draws are some of the unique wind-driven disturbances in the sand prairies, particularly the Nebraska Sandhills, which can profoundly impact vegetation composition and succession within this system. The unifying and controlling feature for this system is that coarse-textured soils predominate and the dominant grasses are well-adapted to this condition. Soils in the sand prairies can be relatively undeveloped and are highly permeable (NatureServe 2007).

This tallgrass system is found primarily on sandy and sandy loam soils that can be relatively undeveloped and highly permeable as compared to Western Great Plains Tallgrass Prairie (CES303.673), which occurs on deeper loams. This system is usually found in areas with a rolling topography and can occur on ridges, midslopes and/or lowland areas within a region. It often occurs on moving sand dunes, especially within the Sandhills region of NE and SD (NatureServe 2007).

It is not advised to include other sand prairies in this description unless they have a similar substrate and climate. The Nebraska Sandhills Prairie is made up of sands than can exceed 300ft in depth – not soil, but sand, so the hydrology and geomorphology of these areas – particularly the long-term aspects, would differ significantly from other sand prairies. Also, the geomorphology of the area and paleogeomorphology has led to ecological patterns unique to these areas.

Vegetation Description

Dominant vegetation includes prairie sandreed (Calamovilfa longifolia), sand bluestem (Andropogon halii), little bluestem (Schizachyrium scoparium), blue grama (Bouteloua gracilis), hairy grama (B. hirsuta), needle-and-thread (Stipa comata) and sand dropseed (Sporobolus cryptandrus). Rooting morphology, photosynthetic pathway (C3 or C4) and mechanisms to avoid transpiration loss are important plant characteristics that may account for the composition, distribution and productivity of plant communities in the Sandhills (Bragg, 1997).

Disturbance Description

Fire, grazing and drought were the primary disturbances in the Nebraska Sandhills. Disturbances were cyclic with the earliest and latest seral stages fluctuating widely on a scale of centuries in accordance with changes in climate.

Grazing: The principal large grazer of the sandhills was most likely bison (Bison bison) which, when occurring in large numbers, would have locally disturbed large areas due both to grazing impact and physical disturbances such as trampling and wallowing.

Another ubiquitous grazer of the Sandhills would have been the plains pocket gopher (Geomys bursarius). Pocket gophers graze largely below ground but their activities also result in localized areas of bare sand. Gopher diets are strongly linked to forbs thus having an effect on species composition.

Grasshopper outbreaks can be significant in some years (i.e. summers following drought years). They presumably consume a significant amount of herbage. This was not modeled, however, due to the limited extent. It might limit fire extent in years when they are present in large numbers, however. They were not modeled, due to lack of data.

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Prairie dog towns were a minor component of the Sandhills landscape occurring where soils were finer textured and in flat uplands and in valleys and the eastern Sandhills where the water table was not high. Unlike elsewhere in the Great Plains mixed and shortgrass prairie, prairie dog towns in the Sandhills are believed to have persisted for decades (20-80yrs) rather than centuries. As prairie dog towns become established in an area, short-statured ecotypes of taller grasses and forbs predominated and plant composition is likely to have shifted from mixedgrass species, such as little bluestem, to shortgrass species, such as hairy grama and buffalograss, and annual forbs.

Prairie dog towns were mostly located only in areas of finer textured soils primarily in the eastern areas of the sandhills or in low areas well above the water table. Where they occurred, prairie dogs grazed vegetation close to the ground; this provided a local firebreak. These towns were unlikely to persist for more than a few decades due to the dynamic characteristics of the sandhills system. Prairie dog grazing separately was therefore not modeled for this system.

Prairie dog towns probably moved with the dunes –meaning, that as a dune/valley system shifted, the dogs would probably have shifted with them, occupying the same place on the landscape. One difference between prairie dogs and other grazers is that they are more stable in where the grazing occurs for longer periods of time (that is, of course, making assumptions about the habits of bison grazing historically in the Sandhills). Prairie dogs are currently present on the Bessey and McKelvie units (near Halsey and Valentine, respectively), although they are not and never will be as widespread as in other grasslands north, south and west. The impact of prairie dogs on the landscape is out of proportion to the percent of area on the landscape they occupy…a keystone species affecting the movement/area affected by at least two other significant disturbances, grazing and fire (Mary Lata, USFS, pers comm.).

Fire: The most extensive fires are likely to have occurred in years with wet springs followed by hot, dry summers when grazing pressure was low. Wet springs would have resulted in more productive and more continuous plant cover (i.e. fuel) that would have supported and expanded fires ignited under dry conditions occurring later in the season. In addition, litter accumulation over several fire-free years would also have supported widespread fire, in any conditions. The litter component, a determining factor in fire size and frequency, is correlated with seral stage. One to five or seven fire-free years produce enough litter to carry another fire. Average rainfall changes by around 10in a year from Alliance to Greeley. It takes longer for continuous litter to accumulate in the sandhills – many areas never do produce continuous litter. Post-fire shifts in species composition depend on the timing and characteristics of a fire. Maximum temperature differences of only 20 degrees C, for example, can change the response of various species to a fire (Lata 2006).

Furthermore, seasonal timing is a major factor determining fire response in systems with both C3 and C4 components. For example a spring fire during the C3 growing season will suppress those species, and often enhance later C4 growth. A late winter fire, before C3 growth begins, has the potential to enhance C3 growth, which may suppress later C4 growth.

In Sandhills prairie, most pixels would be 100% black after fire; therefore, it was modeled as replacement fire. Mixed or low fires could potentially occur on many pixels if: 1. burning under lower end conditions (cooler, damper, lower wind speed), and 2. more importantly, heavier grazing had disrupted fuel continuity, resulting in a "patchy" burn. Patches could be small to large, i.e. square feet to 100s of acres. However, mixed and low severity fires were not modeled for this system. Fires burn when there is some moisture in the ground, minimal wind, miscellaneous small natural fire breaks (open sand from gophers,

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for instance), and/or backing fires…areas that burn patchily. There is less 'top burning' in sandhills fire than in more continuous grasslands because the litter component is so much less contiguous.

Drought: Extended periods of severe drought is likely to have affected both species composition and the stability of the sandhill soil, particularly when compounded by temperature, wind and heavy grazing. These conditions may have lead to the development of blowouts making it difficult for vegetation to re-establish quickly. The occurrence of Blowout penstemon (Penstemon haydenii) suggests long periods when blowouts were common across the landscape although causes resulting in this feature have not been determined

Wind: Another important aspect of this system is its susceptibility to wind erosion. Blowouts and sand draws are some of the unique wind-driven disturbances in the sand prairies, particularly the Nebraska Sandhills, which can profoundly impact vegetation composition and succession within this system. Fire and grazing constitute the other major disturbances that can influence this system (NatureServe 2007). Wind plays a bigger role in sand-based landscapes, but the more significant events occur in conjunction with others that remove cover – drought, trampling, heavy grazing, fire, etc. Wind was therefore not modeled separately.

Heavy grazing, fire and trampling that leads to the removal of vegetation within those areas susceptible to blowouts can either instigate a blowout or perpetuate one already occurring (NatureServe 2007).

The response to disturbance in the Nebraska Sandhills should differ significantly from other sandy sites, since there is little soil structure to renew if it is physically disturbed (such as herds of bison) but, for that same reason, does not compact as other soils do in response to the same disturbance.

Adjacency or Identification Concerns

The Sandhills are dissected by riparian areas which provided fire breaks and affected the movement of bison herds.

Riparian areas include both the Loup River system draining the eastern Sandhills, and several areas of mixed wetland complexes that include areas ranging from sub-irrigated grasslands to deep, open-water lakes of up to several square miles area. The wetland areas will be included within 1495 Depressional Wetlands or within an adjacent tallgrass system.

The sandhills in MZs 39 and 40 would be quite different from the Sandhills in MZ31 in NE. The sandhills in MZ39 should probably be called midwestern sand prairie, as they have western fringed orchids - not much like the sandhills. Valentine National Wildlife Refuge in north central NE might be like the midwestern sand prairie with the orchids, however.

ECOMAP subsection 332Dg area is sometimes erroneously lumped with sandhills, but instead should be broken out as "sand plains." The sand plains area is nearly flat, with shallow groundwater and many areas of sub-irrigation and is rather tallgrass or mixedgrass. Likewise, central NE Loess Hills primarily in subsection 332Cc often is also erroneously confused with sandhills. The southeast boundary of sandhills with Loess Hills is diffuse with soil texture varying from one small divide to the next. Vegetation in the Loess Hills is overall similar to Sandhills, but Loess Hills is more productive historically and in potential veg and therefore should not be classified as Sandhills but rather a grass system (John Ortmann, TNC, pers comm). (Current conditions in Loess Hills grassland system is degraded by chronic improper grazing with lots of C3 exotic grasses having replaced former C4 dominants).

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Note that there are Sandhills wetlands, but they are very small; some should be included within BpS 1495 Western Great Plains Depressional Wetland Systems, but some should just be lumped with an adjacent system such as tallgrass prairie.

As 1148 spreads north to 331F, where there are tallgrass, mesic sandy prairies, still having CALO and ANHI as dominants, and sandy inclusions south of the Black Hills in 331Fb and Buffalo Gap, we could use this 1148 NE model for it, or apply 1094 as more appropriate.

For the drier, coarser soiled prairies in central SD, that are sandy, these should be considered part of 1132. Loess Hills area in 332Cc should also be part of 1132.

In ECOMAP subsection 332Dg, sand plains in northwestern NE should be put into the adjacent grassland system.

In ECOMAP section 332 and 251 (MZ39) - put these sand prairies into 1420 Northern Tallgrass or 1412 N-C Interior Sand Gravel Tallgrass.

For the sand prairie of the Sheyenne Grasslands in southeast ND - put those areas into 1412.

It is likely that uplands today support more herbaceous vegetation than in pre-settlement times. There would be more of class C on the landscape today and less of classes A and B today. This is the result of the first phase of fire suppression and also of local range-management practices that leave adequate cover to prevent wind disturbance of the soil during the dormant season (winter). The Sandhills contain a significant shrub component is some topographical positions (i.e. north aspects of dunes and small protected pockets in the roughest, choppiest dunes). These areas not only provide a more favorable microclimate for woody species, but probably were somewhat fire resistant due to micro-climate and landscape position. Primary shrub species are plums (Prunus spp.) and smooth sumac (Rhus glabra). Both appear to be controlled by longer term moisture cycles, i.e., clones reduce in extent and vigor during drought cycles and rebound during wet cycles. Both species resprout vigorously after fire. Eastern redcedar also is increasingly common in the Sandhills, particularly east of the 101st meridian where surface soil moisture is more often favorable for germination and establishment of bird-vectored seeds. Although a form of eastern redcedar, perhaps intergraded with Rocky Mountain juniper, was native to very restricted areas in and around the Sandhills, modern weed trees are more likely derived from widespread windbreak plantings of selected hardy trees. Major planting began in the 1950s and continues today, introducing cedar to areas that are locally cedar free. When windbreaks begin to bear seed at about 10yrs of age, the first seedlings appear on the more favorable sites of north aspects of steep dunes. Later, as more seed producing trees infest the landscape, the increased seed rain allows some seedlings to establish in other landscape positions, continuing a progression that can be expected to lead to canopy closure over perhaps 50yrs, in the absence of control measures, or catastrophe, such as wildfire.

The Sandhills are remarkably resistant to exotic invasion. Leafy spurge is troublesome in lower, wetter areas and is showing some tendency to move into uplands. See remarks on "exotic" cedars above. In addition, Kentucky bluegrass can dominate in small patches at the base of north-facing dunes, often near or under shrub patches.

There might be more rhizomatous grasses now (Mary Lata, USFS, pers comm).

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Although >90% of the Sandhills region is privately owned, the known fragility of the soils and the cautions used by ranchers to avoid poor grazing practices have allowed for fewer significant changes in the vegetation of the Sandhills compared to other grassland systems (NatureServe 2007).

Native Uncharacteristic Conditions

See comments under "ID concerns."

Scale Description

Droughts could affect the entire region, but deep-percolation of precipitation in the coarse-grained sandy soils would have ameliorated the effects of moderate or short droughts in the uplands. The shallow water table would have protected vegetation of the lowland valleys from the effects of short droughts. During drought periods, grazing pressure would be more concentrated near water sources.

Issues/Problems

Very little data are available from presettlement times, but written accounts describe a much more sparsely vegetated landscape. However, these accounts often followed bison paths which would bias estimates of landscape cover towards more sparse vegetation. The presence of blowout penstemon (Penstemon haydenii), a species endemic to blowouts indicates that bare sand in some form has been present in the area for some time.

Comments

This model for MZ31 was adapted from the model from the Rapid Assessment: R4NESP Nebraska Sandhills Prairie created by Tom Bragg, Mary Lata and Dave Shadis and reviewed by John Ortmann. Model modified quantitatively and descriptively for MZ31. Co-Regional Lead for MZs 31, 39 and 40 modified model and combined classes with modelers' agreement.

Vegetation Classes

Class A **20 %**

Early Development 1 Open

Upper Layer Lifeform

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

Fuel Model

Indicator Species* and Canopy Position

SPCR	Upper
SCSC	Upper
REFL	Upper
MUPU2	Lower

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	20 %
Height	Herb 0m	Herb >1.1m
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform.

Description

Class A (0-999yrs) represents a mix of bare sand, including blowouts and sand draws, and extensive areas of sparse vegetative cover. Once, bared, wind and shifting sand would cause a continued disturbance inhibiting the establishment of annual vegetation. In some years, timely rains and short (1-2 weeks) periods of relative calm winds would have allowed germination and establishment of sufficient annuals to stabilized sand and begin movement to class B. Wind was therefore modeled with a probability of 0.2 taking it to class B (advancing age potentially just one year).

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Class B 60 %

Mid Development 1 Open

Upper Layer Lifeform

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

Fuel Model 1

Indicator Species* and Canopy Position

ANHA	Middle
SCSC	Mid-Upper
CALO	Upper
BOHI2	Lower

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	21 %	70 %
Height	Herb 0m	Herb >1.1m
Tree Size Class	None	

☐ Upper layer lifeform differs from dominant lifeform.

Description

Class B (1-10yrs) represents immediate to three-to-ten year post disturbance conditions. Vegetation consists of resprouting and seedling grass and forbs and maturing. Total bare soil is greater than before the disturbance particularly on upper slopes and dune tops. The vigor of new growth and the specific species affected depend on the season of the disturbance and on pre- and post-disturbance environmental conditions (e.g. available soil moisture).

Litter is low initially but increases until, by year three, there is enough to support fire under average burning conditions. In uplands, where soil-type is dominated by coarse-grained sands with low water-holding capacity, post-disturbance primary production initially decreases thus fire may only carry under ideal conditions. In the later years of this class, fire will carry. Replacement fire was modeled with an approximate eight year return interval, half the time bringing the class back to class A and half the time maintaining this stage.

Under these conditions, grazing is likely to be light in the first few years. In lowlands, with finer-textured soils, primary production is determined largely by moisture availability. Repeated grazing of these areas will prevent succession to class C. In the later part of this stage, there would be moderate grazing by native ungulates and insects. Grazing was modeled with an approximate overall 5-10yr return interval.

Drought, unusually severe fire conditions, or unusual grazing pressure allows the possibility of regression to class A. (Only replacement fire was modeled as bringing this class back to A.)

Class C 20 %

Late Development 1 Closed

Upper Layer Lifeform

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

Fuel Model 3

Indicator Species* and Canopy Position

ANHA	All
CALO	Upper
SCSC	Middle
SPCR	Mid-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.

Description

Class C (11-999yrs) Grasses are well established averaging 85-95% cover in uplands (Bragg 1998), but occurring with as low as 40% canopy cover in some locations. Canopy cover may reach 100% in wetter low areas. Litter accumulates providing continuous fuels for fires thereby increasing the probability of larger fires. This stage rarely persists more than 10yrs but, when it does, woody species such as chokecherry (Prunus virginiana), snowberry (Symphoricarpos occidentalis), and smooth sumac (Rhus glabra) may begin to become established in more protected areas. Since woody plants shade herbaceous species, some disturbance – for example fire or drought – is required to revert this class to an earlier one.

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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

Replacement fire occurs with an approximate return interval of six years, most of the time causing a transition to class B, but sometimes causing a transition to class A.

Grazing occurs on 10% of this class each year and causes a transition back to 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

Fire Regime Group:** **II**

Historical Fire Size (acres)

Avg 7000
Min 1
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	10	2	20	0.1	100
Mixed					
Surface					
All Fires	10			0.10002	

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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**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 3911500 Western Great Plains Tallgrass Prairie

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

General Information

Contributors (also see the Comments field **Date** 7/17/2007

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Modeler 3			**Reviewer**		

Vegetation Type
Upland Grassland/Herbaceous

Map Zone
39

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
PAVI2
SPPE

General Model Sources
☑ Literature
☐ Local Data
☑ Expert Estimate

Geographic Range

This system occurs in the central US including IA, eastern NE, southwest MN, northwest MO, southeast SD and northeast KS and interfaces and mingles on the east with the oak savanna and on the west with mixedgrass prairie.

This would occur in ECOMAP sections 251A and B in MZs 39 and 40.

Biophysical Site Description

This system is found primarily on loam, moderately deep, and rich Mollisols throughout the Western Great Plains Division. These soils tend to be more mesic and deep than the majority of soils within the Western Great Plains and are more typical of the Eastern Great Plains Division (NatureServe 2007).

The area is primarily mollic grassland soils incorporating xeric mesic, and hydric prairie types (Curtis 1959). Xeric prairies were maintained by shallow soils on steep slopes, flat uplands, and ridges where rainwater runoff was greatest resulting in low water-holding capacity. 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 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).

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Vegetation Description

This system is dominated by big bluestem (Andropogon gerardii), Indiangrass (Sorghastrum nutans) and switchgrass (Panicum virgatum) on more mesic sites with prairie cordgrass (Spartina pectinata) dominating the wet sites. Secondary species such as little bluestem (Schizachyrium scoparium), sideoats grama (Bouteloua curtipendula), porcupine grass (Stipa spartea) and junegrass (Koeleria macrantha) occupied the more xeric uplands and soil types and varied in importance. At the western extent of this type, buffalograss (Buchloe dactyloides), blue grama (Bouteloua gracilis) and Dicanthelium spp.increased with grazing. 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. The effect of large ungulates, bison and elk, was less prominent than further west, but no doubt contributed to the patchiness of burns.

Disturbance Description

Fire played an important role in the maintenance of the tallgrass prairie especially in the eastern portion with climatic factors more important to the west (Curtis 1959, Vogel 1974, 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 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. 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. Further, it has been recently suggested that elk populations may have been large enough to have an effect on vegetative composition.

It has also been suggested that in addition to fire, drought, grazing and insect outbreaks (Rocky Mountain locust) would have impacted all classes.

Adjacency or Identification Concerns

As indicated, this system interfaces and mingles on the east with oak savanna and on the west with mixedgrass prairie. 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 mixedgrass prairie is to the west, there would be little effect except in periods of extended drought the percentage of the mixedgrass species would increase.

Some synonymous classifications would be: Eastern part of ECOMAP section 251 (Prairie Parkland - Temperate) (Bailey 1994) No. 74 (Bluestem Prairie) (Kuchler No. 74 (Bluestem Prairie)).

This system is also similar to BpS 1420 Northern Tallgrass. Models for each are very similar.

Today, there is significantly less prairie and more forest with concomitant changes in the fire regime and large ungulate grazing.

There are several successional stages that may have been rare historically that may now be extensive (e.g. prairie areas invaded by woody species). Historically, some woody plant invasion may have occurred but it

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was limited to protected areas close to seed sources such as along the eastern interface with the savanna and around woody pockets and river valleys.

The principal exotic that may be a problem, at least in more mesic locations, is smooth brome. There are others (leafy spurge, Canada thistle, etc.) but the extent to which they occur specifically in MZs 31, 39 or 40 is not known by modeler.

There are also invasive woody species such as buckthorn, Russian olive, and salt cedar. These species pose significant threats in tallgrass prairie.

There may be some (perhaps many) species lost and ecosystems no longer representative of historical conditions.

Native Uncharacteristic Conditions

Large areas of invading woody plants is uncharacteristic of historical conditions.

Scale Description

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

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. Further, it has been recently suggested that elk populations may have been large enough to have an effect on vegetative composition.

Comments

This model for MZs 31, 39 and 40 was adapted from the model from the Rapid Assessment: R4PRTGc Tallgrass Prairie Central created by Daryl Smith and reviewed by Tom Bragg and John Ortmann.

Vegetation Classes

Class A **55 %**

Early Development 1 Open

Upper Layer Lifeform

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

Fuel Model 1

Indicator Species* and Canopy Position

ANGE	Upper
SONU2	Upper
PAVI2	Upper
SPPE	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	50 %
Height	Herb 0m	Herb >1.1m
Tree Size Class		

- [ ] Upper layer lifeform differs from dominant lifeform.

Description

This class lasts just one year. It is a post-fire, post-grazing community from immediately after a replacement fire until one year after the fire. From the blackened state, there is a rapid regrowth of fire positive and fire

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neutral perennial vegetation to maximum height by end of the 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 is present in this class.

Annual burns and sometimes two burns in a single year (spring burns can easily be followed by fall, dormant season burns) can occur in some spots. For fire (and to some extent grazing) in pre-European times, there really are only two basic stages, one immediately after the fire (until fuel accumulates) and a second stage before the next fire (which is any time after a year's growth has accumulated as fuel – a fire can occur as soon as this amount of fuel is available). You can make further subdivisions if you want, such as the time until fuel accumulates to pre-burn conditions but this is difficult to identify (not easily mapped) and isn't really an important factor in burning since a fire can occur with only one growing season's fuel accumulation. It seems that historically, any portion of the mapzone that did not burn would have succeeded to trees some time ago and that, at least theoretically, there would be little if any of this sere in the pre-European landscape. Subsequent stages occur today in the absence of historic disturbances.

Most likely fires occurred at least every 5-7yrs in the Northern TGP (3-4yrs in the central TGP), and more likely to be four to five years or less, even in the west. Virtually all fires (except, perhaps, summer fires) would have been replacement fires. The exception would have been unburned patches in which no burning occurred.

Grazing was modeled as affecting 50% of this class each year. Grazers preference for the younger, more succulent species in recently burned areas created patches with shorter vegetation and an increased forb composition. These patches were less likely to burn and may have changed the overall vegetation structure of this class. It can be inferred that the effect of large ungulates, bison and elk, was less prominent than further west, but their grazing and browsing no doubt affected the composition of the vegetation and burn regime. So long as there were grazers in sufficient numbers, records indicate they would have grazed most of the burned areas.

Because of LANDFIRE mapping rules, canopy cover is arbitrary number. These classes should actually be defined on the ground by biomass, litter and species.

This class can also be distinguished from B based on fuel model (fuel model 3 for class B versus fuel model 1 for class A) and biomass.

Class B **40 %**

Mid Development 1 Closed

Upper Layer Lifeform

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

Fuel Model 3

Indicator Species* and Canopy Position

ANGE	Upper
SONU2	Upper
PAVI2	Upper
SPPE	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	51 %	100 %
Height	Herb 0m	Herb >1.1m
Tree Size Class		

☐ Upper layer lifeform differs from dominant lifeform.

Description

This is the community that develops post-fire, post-grazing after a few months or a year or so.

Historically, there was probably no significant amount of time after burning (assuming spring – summer

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fires) that grazing did not occur.

This stage continues to be dominated by big bluestem (Andropogon gerardii), Indiangrass (Sorghastrum nutans) and switchgrass (Panicum virgatum) on more mesic sites with prairie cordgrass (Spartina pectinata) dominating the wet sites. Secondary species such as little bluestem (Schizachyrium scoparium), sideoats grama (Bouteloua curtipendula), porcupine grass (Stipa spartea), and junegrass (Koeleria macrantha) occupied the more xeric uplands and soil types and varied in importance. At the western extent of this type buffalograss (Buchloe dactyloides), blue grama (Bouteloua gracilis) and Dicanthelium spp increase with grazing. 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.

Fire occurs approximately every 4-5yrrs, causing a transition to A half the time and half the time remaining in B. In dormant season burns, everything above ground is burned. Historically, however, grazing would have resulted in patchy fuel which would have resulted in patchy burns such that only a percentage of the total area would have burned.

Grazing occurs on 50% of the class each year. Grazing is part of the disturbance since historically, anything burned was probably grazed shortly thereafter. Consequently, there probably was never an ungrazed area of any consequence. Also, historic grazing probably did not alter basic species composition, just above-ground growth (similar to fire). However, because grazing occurs after fire, it was modeled to sometimes mimic the fire response, half the time causing a transition back to A (conceivably just one year setback) and half the time remaining in this class.

Wind/weather stress modeled as occurring every 25yrs causing a transition back to class A.

Because of LANDFIRE mapping rules, canopy cover is arbitrary number. These classes should actually be defined on the ground by biomass, litter and species.

This class can also be distinguished from A based on fuel model (fuel model 3 for class B versus fuel model 1 for class A) and biomass.

Class C **5 %**

Late Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 3

Indicator Species* and Canopy Position

RHGL	Upper
CORNU	Upper
ANGE	Lower
PAVI2	Lower

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	20 %
Height	Tree 0m	Tree 10m
Tree Size Class		

☐ Upper layer lifeform differs from dominant lifeform.

Description

This is the woody invasive stage including an ungrazed thatch accumulation stage starting at seven years and that would have been very rare pre-European times. At this point at approximately eight years, trees and shrubs would be beyond the effects of fire or grazing.

With lack of grazing for the long term, the prairie matrix weakens and is succeeded by woody cover of shrubs and trees, depending on proximity of woody seed sources. Probability of a replacement fire = 0.1; surface fire

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= 0.05. However, once this stage is fully wooded, neither fire nor grazing will remove the woody component.

Grazing is modeled to occur on five percent of this class each year. However, once this stage is fully wooded, neither fire nor grazing will remove the woody component.

Wind/weather stress was modeled as occurring every 25yrs, taking this class back to 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.

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	5	3	5	0.2	98
Mixed					
Surface	300	1	300	0.00333	2
All Fires	5			0.20334	

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 3911620 Western Great Plains Floodplain Systems

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

General Information

Contributors (also see the Comments field **Date** 6/1/2007

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Modeler 3			**Reviewer**	Mark Dixon	mark.dixon@usd.edu

Vegetation Type
Wetlands/Riparian

Map Zone
39

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

Dominant Species*

PODE3	CORNU
SALU2	ROSA5
SAEX	FRPE
SAAM2	ARCA13

General Model Sources
☑ Literature
☑ Local Data
☑ Expert Estimate

Geographic Range

This includes the Great Plains river systems from eastern MT west to the Rocky Mountain front. Such river systems include the Missouri, Musselshell, Yellowstone, Teton, Marias and Sun rivers. The major tributaries to these river systems would be in this BpS. This includes the Cheyenne River in MZ31 into MZ29, Belle Fourche in WY into SD, Little Missouri River- ND/SD and Yellowstone River. In MZ30, it would be in section 331Md along the floodplain of the Little Missouri River. This would occur throughout MZ29 in MT, including the Yellowstone River and its major tributaries in Big Horn, Tongue, Powder and the Little Missouri. In MZ30 it would include the Yellowstone and Missouri rivers (ECOMAP sections 331E, 331M).

In MZs 39 and 40, this system goes northwest from ECOMAP subsection 332Bb. It's northwest of Yankton, SD, which is a break in the Missouri River. The 11-mile-wide floodplain with eastern trees stops at Yankton, then going west, the floodplain is one-mile-wide and only has cottonwood as early tree species.

It's difficult to determine geographically where the western model ends and the eastern model (BpS 1469) starts, but it probably starts/ends around Yankton, SD or perhaps up to Fort Randall Dam might be a good dividing line for eastern versus western on the Missouri River.

See Adjacency/Identification Concerns box regarding smaller second and third order prairie streams and where they occur or what they're classified as. Also see Adj/ID box to describe how to distinguish this

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from Rocky Mountain riparian systems and the Eastern Floodplain Systems.

Biophysical Site Description

Alluvial surfaces, usually bare, within broad floodplains are present as low elevation shorelines and barforms. The slightly higher fluvial landform adjacent to the channel forms the first terrace for fluvial dependent species. Over time, laterally migrating point bars form bench platforms that may become late seral stage floodplain forests.

Great Plains riparian and floodplain systems will be lower elevations in the plains matrix.

Dominant communities within this system range from floodplain forests to wet meadows to gravel/sand flats; however, they are linked by underlying soils and the flooding regime.

Vegetation Description

Dominant types in this system are cottonwood and willow. This consists of broadleaf deciduous forests dominated by cottonwood (primarily Populus deltoides), yellow willow, or peach leaf willow and sandbar willow. In the Milk River drainages, narrowleaf cottonwood (Populus angustifolia) is common (but rare or absent in MZs 29 and 30). Narrowleaf cottonwood occurs in upper (intermountain valley) reaches of the Marias and Yellowstone rivers. Black cottonwood (Populus trichocarpa) is found along the Milk and Yellowstone, but only occasionally along the Marias (and not in MZs 29 and 30). Early seral stage phreatophytic vegetation becomes established on low elevation flood deposits; however, long-term survival is possible only on bare, moist sites on slightly higher elevation (1-3m above low water line, or slightly higher elevation possibly due to sedimentation over the original recruitment surface). Other species found in the floodplain riparian zone include sandbar willow, box elder, green ash typically associated with late seral stages. Box elder is present in the Dakotas.

P. deltoides and Fraxinus pennsylvanica are characteristic of Great Plains riparian forests. Fraxinus becomes a dominant in MZ30 riparian areas where it comes in after P. deltoides, grows much more slowly, but persists after P. deltoides because it can recruit into shaded, relatively undisturbed sites.

Green ash commonly forms a subcanopy in older stands and can eventually dominate if stands persist for more than 150-200yrs without major flood disturbance.

PODE is a pioneer species along Missouri River, in central ND, in southeast SD and near Omaha, NE, and is replaced successionally by various combinations of Fraxinus, Ulmus, Acer and Celtis (Hansen et al. 1984). Undergrowth is dominated by SYOC, RHAR (in the uppermost reaches but not in the plains) and other shrubs. Among the grasses, Spartina pectinata, Elymus canadensis and Muhlenbergia racemosa are important.

In Theodore Roosevelt National Park in ND, Poa pratensis is the most important grass, and Melilotus officinalis is the most important forb (Hansen et al. 1984).

Silver sage might be present in this system in the late successional stage. American elm is also a secondary successional species and codominant.

Understory species in these later seral stages may include dogwood, currants, snowberry, wild rose and chokecherry.

The 11-mile-wide floodplain with eastern trees stops at Yankton, SD, then going west, the floodplain is 1-

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mile-wide and has cottonwood and peachleaf willow as early tree species.

With the absence of fire and occasional overgrazing, silver sagebrush has locally invaded upland sites, which is how some range ecologists interpret it. It is unclear how extensive silver sagebrush was historically. The fact that sage grouse were historically collected all the way east to the Missouri River gives cause to wonder about the previous extent of sagebrush (Dave Ode, pers comm).

ARCA/PASM is fairly extensive along the floodplain of the Little Missouri River and along the first and possibly second terrace of some of the more major tributaries of the Little Missouri (Jack Butler, USFS, pers comm).

Disturbance Description

The development and maintenance of this system is dependent on fluvial geomorphic processes such as channel meandering/erosional processes of river flooding, sedimentation, erosion, channel avulsion and barform accretion driven by hydrologic variability. This variability incorporates the features of timing, duration, frequency, magnitude and intensity of flooding. Regeneration of the dominant species (cottonwood and willow) is dependent on flooding and movement of river channels, which creates bare, moist soil needed for seedling establishment. Oxbow and slough development also influence the floodplain system and create variability in plant community composition. Upper terraces have infrequent flooding and scouring events, while the lower terraces nearest the river flood frequently.

Early seral stage development stands are produced on point bars via channel meandering, which occurs most often during moderately frequent high flows. They are also produced in other ways - i.e.: there are two kinds of rivers - meandering as well as occurring on areas of sediment deposition - if river has large flood and bare area created, then the system is established; or via silt deposit that assists establishment (Scott et al 1996). On braided rivers (e.g., Platte), recruitment might occur most often during low flow periods when vegetation colonizes and stabilizes bars within the active channel (Johnson 1994).

Scouring caused by ice jams during the winter, channel meandering, oxbows and slough development greatly influence this system. Ice jams and ice scouring were not modeled.

Extreme drought can also kill cottonwood stands originally established under high-watertable conditions; when drought is severe enough, available water in arid soil textures (coarse river deposits) is exhausted and shallow root systems are no longer able to reach fallen watertable. Such drought was not modeled.

Changes in hydrology due to the activities of beaver are also an important ecological process in the Great Plains Floodplain, particularly on the tributaries (Little Missouri) to the Missouri River, as well as tributaries of the Yellowstone River (Powder, Tongue and Big Horn). Beavers are present on the main stem Yellowstone River, but are not critically important because bank dens are frequently flooded and destroyed. Beaver impoundments kill trees (sometimes over large areas) and may create open water habitat, willow stands or contribute to channel meandering. The effects of beaver ponds on forest dynamics in this system are also poorly understood at the landscape level, especially in the presettlement context. Note that beaver populations might have been maintained at artificially low levels on the Great Plains due to constant harvesting by humans. Beaver activity could have been a large influence in this system historically. It could have contributed to the system going from the mid seral stage to the silver stagebrush stage. However, this would happen if they were old stands on higher terraces close to the channel, but not if they were younger stands on lower, moister terraces. Cottonwoods on lower moister terraces would resprout and there would be a willow-cottonwood, beaver-induced disclimax. Beaver

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damage could be highly extensive in areas in this system (Lesica and Miles 2004; 1999). The effects of beaver activity on forest dynamics in this system are also not well understood at the landscape level, especially in the presettlement context.

Traveling ungulate herds and Native American activities locally impacted seral stage development. However, not enough is known about such disturbance to attempt modeling. Native Americans likely camped along rivers and used fire to attract game - low severity fires in early spring probably more frequent than 50-75yrs (Jack Butler, USFS, pers comm).

This seral community is most affected by fluvial geomorphic processes such as flooding, avulsion and deposition, and channel movement. The floodplain valley was modeled up to the last high terrace that rarely floods to reset to an early successional seral stage. The model does include shallow wetlands, sloughs or oxbows. Deep water habitat and the wetted width of the active river were not included in the model. Different flooding regimes were used in the model. The rivers flood to some extent almost every year. This annual, spring, snowmelt flooding is the primary driver of point bar formation. 50yr or 100yr floods can wipe out point bars, but they form lots of habitat for cottonwood and willow establishment through scouring and deposition. Minor, point-bar forming floods occur almost every year, while serious, scouring, high-terrace depositing events may be 20-50yrs. Flood frequency is also based on location on the floodplain, with higher terraces being subject to longer flood cycles.

Fire was a disturbance mechanism within portions of floodplain, however, the frequency and intensity is unknown. We can, however infer mixed severity fires in general, given the highly variable species and varying fuel amounts and spatial arrangements. The role of fire was less important, with relatively infrequent and patchy, low-to-mixed severity fires. A reviewer (Steve Barrett, personal correspondence) for MT mapzones commented that the overall MFRI was probably approximately 50-75yrs given the presumably abundant ignition opportunities in the neighborhood (i.e.: occasional fires spreading into this BpS from adjacent frequently burned grasslands). The overall MFRI was thus modeled as such. However, Butler commented that Native Americans likely camped along rivers and used fire to attract game - low severity fires in early spring probably more frequent than 50-75yrs (Jack Butler, USFS, pers comm). Upon review in MZs 39 and 40, it was stated that fire was probably not a very important feature on the floodplain forest (Dave Ode, pers comm.). Another reviewer for MZs 31, 39 and 40 stated that these sites were often somewhat protected from fire in three directions by being located within river bends and such sites were considered highly valuable by Native Americans, especially for protected winter occupation, complete with firewood, and even some supplemental forage for a few select horses (ca. 1700 ad and after) in the form of young cottonwood bark. It would have been a fairly trivial exercise for Native Americans to protect these sites from wildfire/upland fires by essentially blacklining grass/tree boundary under appropriate weather conditions. Some such protection probably was provided, given that even light surface fires are extremely destructive to mature cottonwoods. If the highly flammable bark is ignited, it will debark the entire tree. Mature trees do not reprout. Younger trees are easily topkilled, but can still resprount. Mature cottonwood stands might have been, to a large degree a human artifact, i.e. they were protected by native managers. Associated “seral stage” trees, e.g. green ash, elm and hackberry, also are quite fire intolerant and successional pathway could only exist in virtual absence of fire, human regulated (John Ortman, TNC, pers comm).

Adjacency or Identification Concerns

This system is easily identified by using the floodplain which is covered by a 10yr event. Surrounding vegetation could vary from forested to grass prairie transition or bare rock or rock outcrops for instance in the Badlands, White River in SD, and on the Cheyenne River. It is adjacent to grassland with some woody

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draws in the river breaks. In the western part of MZ20, there could be narrowleaf cottonwood and hybrids between this system and narrowleaf.

This system might be very difficult to distinguish from 1469 Eastern Great Plains Floodplain Systems. There is actually only a Midwestern Floodplain and a Great Plains Floodplain, not an Eastern and Western Great Plains Floodplain. The Missouri River downstream from Yankton or even Fort Randall might qualify as Midwestern Floodplain. This 1162 Western Great Plains Floodplain is akin to Great Plains Floodplain, whereas 1469 Eastern Great Plains Floodplain is akin to Midwestern Floodplain. It's difficult to determine geographically where the western model ends and the eastern model starts, but probably around Yankton, SD or perhaps up to Fort Randall Dam might be a good dividing line for eastern versus western on the Missouri River.

Russian olive and tamarisk may be invaders. Tamarisk comes in with cottonwood and willow in earliest post-disturbance stage. Russian olive might affect later successional stages - after ten years, usually at approximately the time that green ash and Rocky Mountain juniper come in. Rocky Mountain juniper also invades along the Little Missouri River in MZ29.

Eastern redcedar is invasive in the floodplain forest along the Missouri River at Yankton and below, and on reaches farther upstream. Indications are that eastern redcedar would have been less prevalent historically than today due to fires and less grazing pressure. Eastern redcedar has increased on floodplains especially due to fire suppression. Also - flood control and channel degradation have been a dominant influence favoring historic red cedar increases on the Missouri River floodplain, at least below Yankton. Many of the eastern redcedar trees on the river below Yankton appear to be 30-40yrs old, tying in well with the period that the dams have been in place. Frequent flooding likely kept eastern redcedar scarce on lower floodplain surfaces in the pre-dam era. How far north and west eastern red cedar would have occurred along our rivers originally is questionable (Gary Larson, pers comm).

Leafy spurge, smooth brome and Canada thistle, might invade also, especially along lower reaches. Russian knapweed might also invade.

The natural flooding frequencies have been changed by the modern water control structures (dam and irrigation projects). Flooding intensity has been altered by construction of small impoundments on tributaries as well as larger impoundments on the main-stem rivers. The mainstem Missouri River effectively does not flood any more. Decreased flood frequency along the Little Missouri River decreased cottonwood abundance and increased distribution of silver sage in MZ29 currently. However, this trend has just started - i.e.: increase of silver stage today vs historically.

Agricultural activities have change seral development and introduced invasive plant species to the BpS.

Woodcutters along the system operated from the earliest days (1860s) to supply wood to the paddlewheelers plying the river. They cut many of the early stands along the river and perhaps threw the balance of this system.

There are thousands of smaller dams on watersheds in addition to the large control structures that are altering hydrology today.

American elms are mostly gone today in some areas. On the river downstream of Yankton, however, elm is still a very common species, but does not grow to be a large tree anymore because of Dutch Elm

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Disease. It is likely, however, that the importance value and average diameter and height of elm has decreased substantially.

Livestock grazing is now different versus historically. The effects of cattle versus bison grazing on the floodplains is very different.

Currently, unpalatable sagebrush cover might be higher today, but chokecherry and associates might be getting wiped out. Bison would have grazed on top and wouldn't have hung out in the floodplain, whereas cattle are there regularly. Depending on management, cows can graze all tree and shrub seedlings, and the seedling re-establishment is episodic, and now re-establishment is stretched out further due to the livestock. They are removing much of the woody vegetation, and they are also hammering the grassland more intensely (Dave Ode, pers comm.).

Johnson (1992), in a study of Missouri River floodplain forests in central ND, determined that the pre-settlement forest was, in fact, dominated by early successional stages. He reports that young pioneer stands (<40yrs old) comprised 47% of the forest, while older pioneer stands (40-80yrs. old) comprised 25% of the forest; that transitional forest (80-150yrs old) comprised 21% of the forested acreage and that equilibrium stands (dominated by green ash,elm, oak, etc.) (>150yrs.old) comprised only 7% of the forested acreage. Johnson (1992) also demonstrated that with construction of Garrison Dam and subsequent cessation of flooding, there is a continuing shift to older forest stages and very little recruitment of new, early successional forest; the very types that once dominated the Missouri River floodplain and provided habitat for its varied native wildlife.(from Ode 2004).

Over the past 37yrs, much has changed in the cottonwood forest of LaFramboise Island in SD. As the density of cottonwoods has declined (at a rate of about 2 per acre per year), the number of junipers and, to some extent, green ash have dramatically increased. In cottonwood forests throughout much of the upper Missouri River Valley, green ash is one of the most important tree species to colonize cottonwood forests and, over time, becomes the dominant forest tree (Ode 2004). Whatever the dominance of green ash in the future forest, it will likely be overwhelmed if not over-shadowed by the massive number of junipers which are now developing in the LaFramboise Island forest understory (Ode 2004). Cottonwood is declining.

Junipers are notoriously vulnerable to fire. On the presettlement landscape of the northern plains, where prairie fires were frequent events, juniper woodlands were restricted to fire-protected environments like river breaks, badland escarpments, buttes, and islands (Ode 2004).

This system should be distinguished from 1159 by geographic range/ecoregions. The Great Plains Floodplain systems are in the Northwestern Glaciated Plains and the Northern Great Plains; the Rocky Mountain Montane Riparian systems are in the lower elevations (i.e. not alpine) of the Northern and Middle Rockies, some of which occur as isolated mountain ranges in the Great Plains. Broadly generalized, the GP Floodplain systems typically have broader floodplains and more terrace development.

Also - montane riparian systems of central MT and probably the Black Hills too will have steeper gradients, narrower floodplains, and be dominated by Populus angustifolia or P. x acuminata (the hybrid between plains and narrowleaf cottonwood), as opposed to P. deltoides for Great Plains floodplains. Rivers like the Powder and Tongue start as montane rivers and become Great Plains rivers.

There might be some difficulty distinguishing the Floodplain Systems from the Riparian from the Wooded Draw/Ravines - and where to assign smaller, second and third order prairie streams. The second and third

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order prairie streams can sometimes have cottonwood and be like small rivers (Riparian, Floodplain); sometimes they are dominated by other woodies such as water birch, boxelder, green ash (Wooded Draw/Ravine) and willows, depending on how far east you go; sometimes they have very few woody plants other than silver sagebrush. Drainages that just don't have the area to get a good flood would probably have been some sort of woody draw, dominated by green ash or other woodies like hawthorn or chokecherry in the more western part of the Great Plains. In terms of assigning the drainage to one or the other type of system, it would depend on basin size.

Rivers and streams that have had impoundments (current conditions) for 50yrs or more probably have more class D and E than presettlement but less class A and B. Class A and B currently has tamarisk. Class C and D have Russian olive currently. Several exotics, such as Canada thistle, Kentucky bluegrass and quackgrass are ubiquitous in classes B through E currently.

Native Uncharacteristic Conditions

Rivers such as the Missouri below Fort Peck Dam and the Big Horn and Tongue below their dams probably have more late-seral and less early-seral vegetation because of the reduced flooding frequency and severity.

Scale Description

This system consists of a landscape adequate in size to contain natural variation in vegetation and disturbance regime. This BpS occurred in a linear dimension along the Missouri River floodplain and Little Missouri River (MZ30), with smaller areas covered in tributary rivers and streams. Wetland complexes include oxbow lakes, slough and marshes.

Issues/Problems

Assumptions: Rapid Assessment model developed with the recognition that the Great Plains Floodplain forest (cottonwood-willow community) is a seral community. This seral community is most affected by fluvial geomorphic processes such as flooding, avulsion and deposition, and channel movement. The model does include shallow wetlands, sloughs or oxbows. Deep water habitat and the wetted width of the active river were not included in the model. Flood frequency for a class is based on location on the floodplain, with higher terraces being subject to longer flood cycles.

Comments

This model for MZs 31, 39 and 40 was adapted from the model from the same BpS 1162 from MZs 29 and 30 created by Peter Lesica and reviewed by Carolyn Sieg and Jack Butler. Quantitative changes made for MZs 31, 39 and 40 due to different conception of species and alternative climax stages (Class E). Regional Lead Elena Contreras made quantitative changes to model based on conversations with experts.

This model for MZs 29 and 30 was adopted from the same BpS from MZ20 created by Peter Lesica and Vinita Shea and reviewed by Brian Martin, Steve Cooper and Linda Vance. Slight model changes made.

This model for MZ20 was adapted from the Rapid Assessment model R4NOFP Great Plains Floodplain created by George Cunningham (gcunningham@mail.unomaha.edu) and reviewed by John Ortmann (jortmann@tnc.org). The model for MZ20 was modified greatly descriptively and quantitatively by Vinita Shea (vshea@blm.gov) and Ben Pratt (ben_pratt@fws.gov). The model is also reflective of the upper Missouri River region. Upon review for MZ20 by Peter Lesica, Brian Martin and Steve Cooper, other major quantitative changes were made and successional classes were changed to encompass the silver sage component of class E instead of a green ash community, which was thought to not exist in MZ20. Other

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reviewers for MZ20 were Steve Barrett.

Vegetation Classes

Class A 15 %

Early Development 1 All Structure

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

PODE3	Upper
SAEX	Upper
SALU2	Upper
SCHOE6	Low-Mid

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	50 %
Height	Tree 0m	Tree 5m
Tree Size Class	Sapling >4.5ft; <5"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

The upper layer lifeform is comprised of a seedling and sapling shrub (willows) and tree component. Trees might be more abundant/frequent. Shrubs of any cover and 0-1m are in this class.

Description

This class is created by deposition, stream meander changes, point bar formation and scouring.

The upper layer lifeform is comprised of a seedling and sapling shrub (willows) and tree component and dominated by a young canopy of tree saplings and shrubs after a few years. Trees might be more abundant/frequent. Salix amygdaloides (peachleaf willlow) is also an upper layer indicator species.

This class consists of sandbar willow. Salix interior is invariably the first which makes its appearance on the newly made lands on the borders of the Mississippi and Missouri rivers, and seems to contribute much towards facilitating the operation of raising this ground still higher; they grow remarkably close and in some instances so much so that they form a thicket almost impenetrable (from Meriwether Lewis during the Lewis & Clark expedition in 1804 to 1806, from Ode 2004).

This includes pioneer tree and shrub species of cottonwoods and willows. The understory is highly variable and consists of bare sand, annuals, or perennial hydrophytes. Species would include various grass, sedges, and rushes. Annuals become less and less common after 10yrs as the rhizomatous perennials take hold. There is an herbaceous understory of sedges (bulrushes) and native annuals in wet areas. In the early few years of this stage, most of the area is bare sand. This class ranges from age 0-4yrs for the first part of this class, then 5-14yrs for the second part of this class.

Most of area is seasonally flooded. Much bare, wet-alluvium habitat for cottonwood establishment is created each year during spring floods. However, most all of these will be swept away by the next year's flood in the early part of this class. It is probably only every 10-20yrs that flooding occurs up high enough on point bars and low terraces to establish cottonwoods and then allow them to escape flooding until they are large enough to persist - in the early part of this class.

During the second part of this class, at age 5-14yrs, minor flooding occurs every 20yrs, advancing this stage to the next; deposition causes the terrace to build and become higher and drier. This was modeled as alternate succession. Lack of flooding actually maintains the stage.

Major flooding occurs every 50yrs, bringing it back to the beginning of this stage. This was modeled as wind/weather stress.

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Beaver disturbance occurs in this class. The closer to the river, the more likely it is. It was modeled as "optional 1". Beavers, however, do not have as much of an impact in stands less than 10yrs old unless there is nothing else in the area. Beaver activity is quite variable. It was modeled as occurring on one percent of this class on the landscape each year, maintaining this class.

After 15yrs, this class succeeds to the mid-development closed stage.

Johnson (1992) states that young pioneer stands (<40yrs. old) comprised 47% of the forest historically.

Class B **30 %**

Mid Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

PODE3	Upper
SAAM2	Mid-Upper
SALU2	Middle
FRPE	Low-Mid

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.

Description

This stage develops as the stand starts to mature. This community tends to be partially opened, with scattered cottonwoods and willows. Stands of cottonwoods 20-50yrs old can be fairly dense, although there are usually some openings. The shrub layer is highly variable and may include species such as rose, snowberry, chokecherry and dogwood.

Green ash begins to establish in cottonwood stands when they are approximately 20yrs old (Lesica and Miles 1999).

The understory vegetation is highly variable. Age is 15-50yrs, succeeding to class C, a late closed stage.

Willows slow current and create deposition on top. The vegetation helps anchor and causes deposition which decreases flood frequency. Flooding leading to deposition occurs every 50yrs, promoting succession to the next stage by raising the level of the terrace (modeled as alternate succession). Major flooding also occurs approximately every 50yrs, bringing this class back to the early class A stage (modeled as wind/weather stress).

Replacement fires were modeled as occurring every 150yrs. It would probably only burn in drought, as fires would be very rare. It has been suggested that stand replacing fires might not occur in this class because it might be too wet for fire. However, due to lack of data, replacement fires were kept in the model. It is questionable whether replacement fire would set this stage back to the beginning of class A, as the terrace would be too high and dry to provide conditions for successful establishment of cottonwood and willow from seed. If the cottonwoods resprouted, it would be more like the middle of class A because the understory would be more mature than the beginning of class A; if the cottonwoods didn't resprout, it would probably just be a willow stand. Replacement fire was however modeled as taking this class to class A.

Low severity and mixed fire also occur every 100yrs, combined, and would not cause transition to another stage.

Beaver disturbance occurs in this class. The closer to the river, the more likely it is. It was modeled as

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"optional 1". Beaver activity is quite variable. It was modeled as occurring on one percent of this class on the landscape each year, thus maintaining this class.

It has been suggested that Native Americans likely burned (low severity fires) these areas more often than every 100yrs. However, another reviewer questioned that and stated that they probably didn't burn these areas but rather the surrounding area, since this area would be too difficult to burn due to too much shade and humidity. Also, some sites were likely heavily grazed by bison (low severity fire sites) and horses near camps. However, the model was retained as is, as no confirming feedback was received.

Class C **35 %**

Late Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

PODE3	Upper
SYOC	Middle
FRPE	Low-Mid

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	61 %	80 %
Height	Tree 25.1m	Tree 50m
Tree Size Class	Very Large >33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Tree height maximum probably only goes to approximately 30-35m. Western portions will be shorter.

Description

This class is a mature, late seral closed canopy cottonwood floodplain forest. Overstory is dominated by cottonwood and green ash. Box elder is a frequent component of this class for MZs 39 and 40 but is not as common as green ash. (Some modelers/reviewers thought that the system is becoming drier in this class allowing western wheatgrass to come in; however, others questioned that.)

Ecological studies along the Missouri River in central ND have documented a similar successional pattern as that for at least four studies along the Missouri River in southeastern SD, which have described aspects of a successional sequence that begins with colonization by cattails or sandbar willow, develops through transitional phases to a plains cottonwood dominated forest, and finally, in the absence of stand replacing floods, develops into a mixed deciduous forest containing aging cottonwoods, green ash, boxelder, bur oak (Johnson 1950, Heckel 1963, Wilson 1970) and American elm (Johnson, et al. 1976). (from Ode 2004). This was therefore modeled as a successional pathway to class D. Some cottonwood stands follow the successional pathway and proceed to class E's silver sage component, which was modeled as alternate succession. Others have enough green ash that the next class, in this case class D, is dominated by green ash and Symphoricarpos occidentalis. Some stands would be a mosaic of these two late-seral types.

This class lasts from age 51-150yrs can then succeed to class D. This class probably only succeeds to class E's silver sage component with high flood and not a frequent occurrence, thus for MZs 39 and 40, it was modeled as alternate succession instead of the main successional pathway as was done in MT and western Dakota mapzones. Historically, this system might have even succeeded to juniper. When there is a 100yr flood and high sand deposits occur, cottonwoods die, and then dry stands occur. It is then too dry for green ash, so it might succeed to juniper. In these cases, it was islands – so they were protected from fire. Those that would form on terraces would probably be affected by fire. But islands didn't burn and so juniper was retained.

Note that the forest might not succeed to class E in eastern SD, and rather it might remain in class C or D.

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Class E is more appropriate for western parts of the mapzones where later successional species are scarcer.

Minor flooding occurs every 10-20yrs. Minor flooding raises the level of the terrace. Because this is the last stage in this cottonwood portion of the system, this minor flooding was modeled as wind/weather stress, causing no transition. Major flooding occurs every approximate 200yrs, bringing this class back to class A. This was modeled as wind/weather stress.

Replacement fire occurring every 150yrs and taking this class to class E's silver sage component was originally modeled in MT and western Dakota mapzones. However, because that fire was speculative, and because review for MZs 39 and 40, it was thought that those events do not occur often, and because too much was thought to be going into class E, that replacement fire was removed for MZs 39 and 40. It is thought that drought might convert this system to sagebrush, but that is speculative, and geographical climaxes vary.

Low severity fire was also modeled as it was in class B, causing no transition. Mixed severity fire was also included with the same probability as low severity, every 100yrs. It is thought that mixed severity fire might cause a more open, drier stand that would allow invasion of silver sagebrush earlier, bringing it to E earlier; however, that was not modeled for MZs 39 and 40, as it is speculative.

Optional 2 in this class represents erosional processes of river meandering that would bring this class eventually back to class A. The class/system will first be part of the river, but then will succeed to class A or a point bar state. This occurs with a frequency of several hundred years and was modeled at a frequency of 200yrs.

River meanders back and begins to cut away at the banks whereon a mature or old-growth stand of POPDEL exists and the living trees slowly are undercut and ultimately fall into the stream.

Beaver disturbance occurs in this class. The closer to the river, the more likely it is. It was modeled as "optional 1". Beaver activity is quite variable. It was modeled as occurring on 1% of this class on the landscape each year, maintaining this class.

Johnson (1992) states that older pioneer stands (40-80yrs old) comprised 25% of the forest; that transitional forest (80-150yrs old) comprised 21% of the forested acreage and that equilibrium stands (dominated by green ash, elm, oak, etc.) (>150yrs old) comprised only seven percent of the forested acreage historically.

Class D **10 %**

Late Development 2 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Description

Indicator Species* and Canopy Position

FRPE	Middle
ACNE2	Middle
PODE3	Upper
SYOC	Lower

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.

The trees are actually shorter as one moves west. Green ash and cottonwood in the central and western Dakotas are almost half the size of those in the Midwest.

*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

The trees are actually shorter as one moves west. Green ash and cottonwood in the central and western Dakotas are almost half the size of those in the Midwest.

This class was based on R4NOFP class E. It is found along the upper terrace that has been protected from most flood events, except for rare high intensity flooding. Species composition increases towards south and east within the region. Overstory species include hackberry, green ash, and elm. Understory species include vines and poison ivy.

In the absence of stand replacing floods, this class is what has developed - a mixed deciduous forest that may contain aging cottonwoods, green ash, American elm, boxelder, bur oak, and eastern red cedar (Johnson 1950, Heckel 1963, Wilson 1970), which is more prominent in the east but still present in the Dakotas. Ecological studies along the Missouri River in central ND have documented a similar successional pattern ultimately resulting in a forest dominated by green ash, boxelder, bur oak, and American elm (Johnson, et al. 1976). (from Ode 2004).

Class D's components of hackberry, slippery elm and bur oak are present downstream from Yankton in the Dakotas. These species occur in central to eastern ND. In western ND (and probably much of western SD too) species are green ash, American elm, boxelder and eastern redcedar and Juniperus scopulorum.

Hansen et al. (1984) state that other dominants are Toxicodendron rydbergii and Elymus canadensis.

The FRPE/SYOC association is an edaphic climax on the floodplain adjacent to the Little Missouri River and its major tributaries. PODE currently dominates many stands but is no longer reproducing. It will be replaced by FRPE. The larger trees, some 6-7 dm dbh are PODE, but the young trees establishing in the stands are FRPE. JUSC is tallied with the tree species, although it's an understory species in the closed forest. Its current abundance is attributed to adequate light penetrating to the shrub and herb layers of the cmty as a result of wide spaceing of the old Populus. Along the Missouri River, in central ND, SE SD, and near Omaha, NE, PODE is a pioneer species and is replaced successionally by various combos of Fraxinus, Ulmus, Acer and Celtis. Among the grasses, CALO, ELCA and MURA are important (Hansen et al 1984).

The disturbances are those from R4NOFP: Major flooding events can bring this class back to A (0.004 probability - every 250 years), modeled as wind/weather stress. Flooding events can also cause a transition back to C (0.005 probability - every 200yrs), modeled as wind/weather stress.

Mixed fire occurs every 50yrs but causes no transition.

Dominants of the green ash/western snowberry stands can resprout after fire. However, a very hot fire can kill the green ash (Lesica 2003), in which case it would probably become a stand of western snowberry-silver sagebrush-western wheatgrass (not modeled here).

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Class E **10 %**

Late Development 3 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☑ Shrub
- ☐ Tree

Fuel Model

Indicator Species* and Canopy Position

ARCA13	Upper
SYOC	Upper
PASM	Middle

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	11 %	40 %
Height	Shrub 0m	Shrub 1.0m
Tree Size Class	None	

☐ Upper layer lifeform differs from dominant lifeform.

There could also be junipers in this class, so those could be trees overtopping the canopy.

Description

Note that the forest might not succeed to this class E in eastern SD, and rather it might remain in class C or D. Class E is more appropriate for western parts of the mapzones where later successional species are scarcer.

This stage in MT and western Dakotas mapzones was modeled as a silver sagebrush community. For MZs 39 and 40, it is thought that there are a few historical alternative ends, of which silver sagebrush is only one. Therefore, class E is a combination of the alternative ends. Silver sage is a common terrace shrub, but the events causing this system to move there are infrequent, and therefore the previous 25% in this class E from MT mapzones did not apply in the Dakotas. Another alternative end is this system going to Juniper. These are examples of where the successional path might take a different turn due to rare flood events or geographically varying climaxes and variations dependent on habitat.

The cedar stage/forest is also another stage that might have been present historically but not anymore – in all stages of this system (Dave Ode, pers comm).

The silver sagebrush climax community occurs on river terraces and along larger streams. It has been noted (Steve Cooper, personal correspondence) that the usual case in this system is for plains cottonwood to die out and for the stand to go to silver sagebrush domination with western wheatgrass in the undergrowth or western snowberry and rose (Rosa spp) with grasses (mostly PASSMI). That is what is therefore modeled here. It is thought that before this stage gets to silver sagebrush, there might be an intermediate stage dominated by western wheatgrass and snowberry before silver sagebrush establishes in significant amounts. However, due to the limitations of the five-box model, this intermediate stage was not modeled.

This stage starts at age 100yrs to account for the low probability of the alternate successional pathway from C.

This class is less likely to have depositional flooding than other stages. It was therefore not modeled here.

Major flooding events were modeled as wind/weather stress occurring every 250yrs, bringing this class back to A.

Optional 2 in this class represents erosional processes of river meandering that would bring this class eventually back to class A. The class/system will first be part of the river, but then will succeed to class A or a point bar state. This occurs with a frequency of several hundredyrs and was modeled at a frequency of 400yrs.

Replacement fire was modeled at every 50yrs, similar to other silver sage communities, but maintaining this stage, as this class is stable, and the silver sagebrush resprouts and thus maintains this stage.

Note for mappers: although height and cover overlap with class A, species are completely different. This is no

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longer a PODE3 community.

It is thought that this stage might be more prevalent currently versus historically due to impoundments increasing the silver sage distribution.

It is questionable as to how much this class occupied of the historic landscape. In MT and western Dakota zones, it was modeled as 25%; however, it was thought that that was too much for the Dakotas.

Johnson (1992) states that older pioneer stands (40-80yrs old) comprised 25% of the forest; that transitional forest (80-150yrs old) comprised 21% of the forested acreage and that equilibrium stands(dominated by green ash, elm, oak, etc.) (>150yrs old) comprised only seven percent of the forested acreage historically.

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	225			0.00444	25
Mixed	115			0.0087	48
Surface	200			0.005	28
All Fires	55			0.01814	

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
- [x] Other (optional 1) beaver
- [x] Other (optional 2) erosional processes of river meandering

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LANDFIRE Biophysical Setting Model

Biophysical Setting 3913010 Boreal Aspen-Birch Forest

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

General Information

Contributors (also see the Comments field **Date** 8/5/2007

Modeler 1 Brendan Ward bward@fs.fed.us **Reviewer** modeler was reviewer

Modeler 2 **Reviewer**

Modeler 3 **Reviewer**

Vegetation Type

Forest and Woodland

Dominant Species*

POTR5 DILO
BEPA
ABBA
ACRU

General Model Sources

☑ Literature
☑ Local Data
☑ Expert Estimate

Map Zone

39

Model Zone

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

Geographic Range

The sub-boreal aspen birch forest described here is documented throughout northern and northeastern MN. It is found in ECOMAP sections 212M and 212L and subsection 212Nd (Aaseng et al. 2003).

In MZs 50 and 51, the aspen and birch component of this system is considered seral to other upland BpS units, including 1302, 1362, 1366 and 1407. The conifer component of this system is also indicative of lowland systems such as 1481.

Biophysical Site Description

This type occurs on a variety of soil types within its range. It is common on scoured bedrock terrain, stagnation moraines and till plains and outwash plains (Aaseng et al. 2003). Within bedrock terrain it occurs on deeper soils 36-40in (Ohmann and Ream 1971).

Vegetation Description

Major deciduous species are trembling and bigtooth aspen, paper birch and red maple. Trembling aspen is often the most abundant species in early successional stages while bigtooth aspen, paper birch and red maple are common minor associates. Species considered late successional such as balsam fir, northern white-cedar, and black and white spruce are usually present though not abundant during the early successional stages. By the later successional stage stands consist mainly of balsam fir with lesser components of aspen, birch, spruce and sometimes cedar. Historically, white and red pine were more common on the landscape prior to significant logging events in the late 1800's and early 1900's, and substantial areas were converted to this vegetation type. Isolated red and jack pine are likely remnants of previously logged sites, and may indicate a pine BpS (1362-1 or 1362-2) rather than this type.

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Shrub cover is often dense especially on rich sites, with beaked hazel being the most abundant tall shrub followed by mountain maple, round-leaf dogwood (Cornus rugosa) and green alder. Low shrubs are not always abundant and consist of bush honeysuckle, blueberry and dewberry. Depending on shading and site physiography the ground layer varies in abundance and diversity. Moist and more-open sites are more abundant, containing numerous herbs. Large-leafed aster is normally most abundant with wild sarsaparilla, bluebead-lily, star flower (Trientalis borealis), twisted stalk, lily-of-the-valley, ground pine (Lycopodium dendroideum) and club moss (Lycopodium spp.). As conditions become drier and more nutrient-poor, blueberry, bracken fern, veiny pea (Latyrus venous) and bunchberry become common. In later successional stands the herb layer becomes sparse, though still having many of the same species, and coverage of Dicranium and Schreber's mosses increases (Heinselman 1996, Ohmann and Ream 1971).

Disturbance Description

The natural fire regime is one of stand replacement fires every 70-110yrs (Frelich 2002). Beginning with an aspen-birch early successional stage, spruce and fir present in the stand will increase in abundance over time. After 70-80yrs, the overstory aspen and birch trees begin to break apart due to insects, disease and windthrow. The conifers are usually well established in the understory at this point and will soon assume dominance in the overstory. The stand becomes more susceptible to fire and spruce budworm attacks as conifers increase in abundance. Periodic outbreaks of spruce budworm will kill much of the conifer overstory increasing the susceptibility to fire even more. It is only a matter of time before the stand burns. The post fire stand composition typically retains the composition of the former parent stand however with a greatly shifted dominance. Assume birch, aspen and maple are still relatively abundant in the pre-fire stand, the post-fire stand will consist of a dense thicket of birch, aspen and maple sprouts with scattered spruce, fir and pine. The abundance of the latter species depends greatly on the availability of nearby seed sources typically in unburned patches.

Adjacency or Identification Concerns

This type encompasses a variety of communities described by other authors (Frelich 2002, Hop etal. 2001, Heinselman 1996, Ohmann and Ream 1971), namely, aspen-birch, aspen-birch-boreal conifer, birch-fir, maple-aspen-birch, spruce-fir-aspen and spruce-fir-birch-cedar. Each of these can be considered a different successional stage of the same community with some variation. This type is commonly referred to as mixedwood in Canada and refers to all successional stages.

Native Uncharacteristic Conditions

Scale Description

Historical fire size ranged from small acreages (<1000ac) to extremely large events (>100,000ac or 40,000ha) (Heinselman 1978).

Issues/Problems

Comments

This model for MZs 39 and 40 was adapted from the model from MZ41 created by Randy Swaty and reviewed by Dave Cleland, Mark White and Brendan Ward. Quantitative changes to Swaty's model were made by Brendan Ward in order to better represent the system; these changes were suggested during Ward's review for Great Lakes but were incorporated for Great Plains, MZs 39 and 40. No further review for MZs 39 and 40 was obtained, as we were notified of this system's occurrence in these zones at a late date, and this system is just on the outskirts of these mapzones.

The model for MZ41 was created from scratch by Randy Swaty rswaty@tnc.org.

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Vegetation Classes

Class A 32 %

Early Development 1 All Structure

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

POTR5	Upper
BEPA	Upper
ABBA	Lower

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	100 %
Height	Tree 0m	Tree 10m
Tree Size Class	Sapling >4.5ft; <5"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

This is the regeneration phase often characterized by dense thickets of aspen, birch and maple sprouts and suckers. This is an even-aged cohort with sporadic inclusions of unburned patches.

This stage ranges from age 0-30yrs. Class A succeeds to class B.

Replacement fire is modeled at 110yrs. Probability is lower than that for the late development classes due to the higher fuel moisture and lower availability of fuels (esp. conifer ladder fuels).

Class B 29 %

Mid Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

POTR5	Upper
BEPA	Upper
ABBA	Low-Mid

Structure Data (for upper layer lifeform)

	Min	Max
Cover	71 %	90 %
Height	Tree 10.1m	Tree 25m
Tree Size Class	Pole 5-9" DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

The stand moves through the stem exclusion phase and approaches "maturity". Most of the tree species that will occur in this type are now present. Aspen and birch dominate the overstory. Pines occasionally occur in the upper canopy as well. Balsam fir and spruce become abundant. White cedar occurs in some stands.

This stage ranges from age 31-70yrs. Class B succeeds to class C.

Replacement fire was modeled as occurring every 75yrs. The probabilities are equivalent to those in the late development stages due to conifer fuels.

Class C 17 %

Late Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

POTR5	Upper
BEPA	Upper
ABBA	Mid-Upper
PIGL	Middle

Structure Data (for upper layer lifeform)

	Min	Max
Cover	91 %	100 %
Height	Tree 10.1m	Tree 25m
Tree Size Class	Medium 9-21"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

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The overstory reaches "maturity", aspen and birch near their maximum height. These species still dominate the canopy but begin to succumb to disease and windthrow. The pines begin to overtop the upper canopy. Spruce and fir increase in density to the extent that a stand replacement fire is possible. These species begin to fill gaps in the canopy. Upper and middle canopies are apparent. Spruce budworm outbreaks are possible.

This stage ranges from age 71-110yrs. Class C succeeds to class D. Replacement fire, modeled with a probability of occurring every 75yrs (0.013), will send the system back to class A. Insects/disease (such as spruce budworm) was modeled with the probability of occurring every 33yrs and would maintain the system in this class.

This class should be distinguished from D by species/EVT.

Class D **22 %**

Late Development 2 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

ABBA	Upper
PIGL	Upper
PIMA	Middle
PIST	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	91 %	100 %
Height	Tree 10.1m	Tree 25m
Tree Size Class	Medium 9-21"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

The overstory of aspen and birch breaks up due to windthrow and disease. The gaps are quickly filled with spruce, fir, cedar and birch, which dominate the canopy. Cedar and black spruce are common in the mid to upper canopy. Occasional red and white pine are present as super canopy trees. Other indicators: white cedar and Betula papyrifera could still be present at the beginning of the class, but by the end, the original cohort of aspen and birch are all but gone. This class should be distinguished from C by species/EVT.

Spruce budworm outbreaks likely have or will occur. The stand is highly susceptible to fire. If fire does not occur gap phase dynamics drive the system. The supercanopy pine succumb to windthrow. Periodic spruce budworm outbreaks continue to occur (approximately every 31-37yrs (Frelich 2002)).

Replacement fire is modeled with a probability of occurring every 65yrs (0.013) and will send the system back to class A. Insects/disease (such as spruce budworm) was modeled with the probability of occurring every 33yrs and would maintain the system in 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

*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:** IV

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	85			0.01176	100
Mixed					
Surface					
All Fires	85			0.01178	

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 3913020 Laurentian-Acadian Northern Hardwoods Forest

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

General Information

Contributors (also see the Comments field **Date** 8/5/2007

Modeler 1 Brendan Ward bward@fs.fed.us **Reviewer** modeler was reviewer

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

Vegetation Type
Forest and Woodland

Map Zone
39

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 FAGR
ULAM

General Model Sources
☑ Literature
☑ Local Data
☑ Expert Estimate

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

Biophysical Site Description
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.

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 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

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species on more poor soils; however, its presence today likely suggests that the Laurentian-Acadian Pine-Hemlock-Hardwood Forest is a more appropriate 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 MI (Cleland et al. 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 2.0% 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 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 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

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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 WI, 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 1400-2000yrs.

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

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.

The BpS adjacent to this system include 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 honeysuckle occur presently but would not have affected 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 1930's have converted some of this system to red pine monoculture.

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 coarse-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.

Comments

This model for MZs 39 and 40 was adapted from the model from MZ41 created by Peggy Burkman and reviewed by Dave Cleland and Brendan Ward. Quantitative changes to Burkman's model were made by Brendan Ward in order to better represent the system; these changes were suggested during Ward's review for Great Lakes but were incorporated for Great Plains, MZs 39 and 40. No further review for MZs 39 and 40 was obtained, as we were notified of this system's occurrence in these zones at a late date, and this system is just on the outskirts of these mapzones.

This model for MZ41 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 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 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. 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).

Vegetation Classes

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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
POGR4	

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.

All classes (even A) can experience catastrophic windthrow due to rare downburst/tornado events (2500yrs). Decaying aspen stands have a fairly high susceptibility to windthrow too (this starts occurring toward the end of A). Wind interval without subsequent fire of about 2500yrs. Replacement fire (3000-3500yrs) represents a coupled wind and fire event and includes the rare fire events without previous wind.

Class B 3 %

Early Development 2 All Structure

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

ACSA3	Upper
TIAM	Upper
BEAL2	Upper
BEPA	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

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.

All classes can experience catastrophic windthrow due to rare downburst/tornado events, but the rate increases toward D because of increasing susceptibility. Wind interval without subsequent fire of about 2500yrs. Replacement fire (3-3500yrs) represents a coupled wind and fire event and includes the rare fire events without previous wind.

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Class C 15 %

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.

This class succeeds to class D.

All classes can experience catastrophic windthrow due to rare downburst / tornado events, but the rate increases toward D because of increasing susceptibility; it increases after age 75 in class C. Wind interval without subsequent fire of about 1000yrs. Replacement fire (2500yrs) represents a coupled wind and fire event and includes the rare fire events without previous wind.

Class D 78 %

Late Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

ACSA3	Upper
TIAM	Upper
BEAL2	Upper
TSUGA	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 yellow birch, American elm, white ash and hemlock occasional.

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). Wind interval without subsequent fire of about 1000yrs. 33% of windthrow followed by fire would be a 2000yr MFRI (p=0.0005). Replacement fire (especially in D) represents a coupled wind and fire event and includes the rare fire events without previous wind.

Class E 2 %

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.

This class can succeed to class C. Alternate succession to class C can also occur to increase chance of succeeding to C - with a probability of 0.01.

All classes can experience catastrophic windthrow due to rare downburst / tornado events. Wind interval without subsequent fire of about 1000yrs. Replacement fire (2500yrs) represents a coupled wind and fire event and includes the rare fire events without previous wind.

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	2500			0.0004	95
Mixed					
Surface					
All Fires	2488			0.00042	

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

LANDFIRE Biophysical Setting Model

***Biophysical Setting* 3913100** **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** 8/5/2007

Modeler 1 Brendan Ward bward@fs.fed.us **Reviewer** modeler was reviewer

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

Vegetation Type
Forest and Woodland

Map Zone
39

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

This system occurs in Province 222. In MI, this occurs in ECOMAP section 222J, and in WI in sections 222K and 222L.

Historically, this type was quite extensive in MI, IN, IL, MO, IA, WI and MN (NatureServe 2007).

The Dry-Mesic Oak Forest occurs throughout the Lakes Region including northwest MN through central MN and into northern WI. It occupies the tension zone between prairies to the west and south and the forests of the Lakes region. This system occurs on the Allegheny, Piedmont, and Cumberland plateaus. It continues west to the Ozark and Ouachita Highlands.

In MZs 39 and 40, it might occur in coulees and river breaks or just on the outskirts of MN, on the eastern edges of the mapzones grading into MN.

Biophysical Site Description

This system is found throughout the glaciated regions of the Midwest, typically in gently rolling landscapes. It can occur on uplands within the prairie matrix and near floodplains, or on rolling glacial moraines and among kettle-kame topography. Soils are typically well-drained Mollisols or Alfisols that range from loamy to sandy loam in texture (NatureServe 2007).

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-

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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 Woodland (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. 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.

Vegetation Description

Forest cover can range from a dense to moderately open canopy and there is commonly a dense shrub layer. Fire-resistant oak species, in particular Quercus macrocarpa, Quercus rubra, Quercus velutina and/or Quercus alba, dominate the overstory. There are also varying amounts of hickory, Carya spp., including Carya ovata, Carya cordiformis and Carya alba (= Carya tomentosa), are diagnostic in portions of the range of this system. Depending on site location and overstory canopy density, the understory may include species such as Corylus americana, Amelanchier spp., Maianthemum stellatum, Caulophyllum thalictroides, Laportea canadensis, Trillium grandiflorum, Aralia nudicaulis and Urtica dioica. Occasionally, prairie grasses such as Andropogon gerardii and Panicum virgatum may be present (NatureServe 2007).

There might also be varying amounts of black cherry (Prunus serotina) and sassafras (Sassafras albidum). American chestnut (Castanea dentata) was once dominant or codominant in the very southeastern portion of southern MI. Common low woody shrubs include brambles (Rubus spp.), black currant (Ribes cynosbati). Graminoid species such as Carex pensylvanica, Danthonia spicata, Andropogon gerardii are also common.

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.

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 and Bowles 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

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averaging every 15-25yrs.

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.

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.

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).

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 possiblity of germination and recruitment of oaks.

Periodic drought, intensified by local conditions, such as slope, southern exposure, or sandy soil, also inhibit growth of mesophytic trees (NatureServe 2007).

Some feel that catastrophic stand replacement fires occurred every 80yrs with low-intensity underburns every 10yrs (Phil Graeve, pers comm).

Adjacency or Identification Concerns

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

This system is distinguished from other forested systems within the region by a dry-mesic edaphic condition that is transitional between dry oak forests and woodlands and mesic hardwood forests, such as

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maple-basswood forests (NatureServe 2007).

With fire suppression, this system expanded into sites formerly occupied by disturbance maintained savannas (Leach & Givnish 1999).

Currently, under the past century's practice of fire suppression, oak-hickory forests are succeeding into a red maple-dominated forest. Continued fire suppression has also resulted in succession to mesic hardwoods, such that in many locations, no oak species are regenerating. Prolific sprouting ability, light, wind-carried fruits, and the tendency to cast dense shade has enabled red maple to outcompete 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.

Current fire suppression likely has allowed for other associates, such as Acer saccharum, Celtis occidentalis, Liriodendron tulipifera, Ostrya virginiana, and Juglans nigra, to become more prevalent, especially in upland areas along floodplains (NatureServe 2007). Due to decades of fire suppression, subcanopies and shrub layersare well-developed by witch-hazel (Hamamelis virginiana), flowering dogwood (Cornus florida), and hop-hornbeam (Ostrya virginiana).

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).

Fire suppression may account for the more closed oak forest (classes D and E) examples of this system with the more mesic understory. It likely has allowed for other associates, such as Acer saccharum, Celtis occidentalis, Liriodendron tulipifera, Ostrya virginiana and Juglans nigra, to become more prevalent, especially in upland areas along floodplains.

Extensive conversion for agriculture has fragmented these systems. Remaining large areas of this system are likely under considerable pressure due to conversion to agriculture, pastureland and urban development (NatureServe 2007).

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.

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 silvicultural 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.

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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.

Comments

This model for MZs 39 and 40 was adapted from the model for 1310 from MZ41 modified by Greg Nowacki and reviewed by Dave Cleland and Brendan Ward. Co-RL, Elena Contreras, for MZs 39 and 40 added in information from NatureServe as well as from other contributor, Phil Graeve. Quantitative changes to Nowacki's model were made by Brendan Ward in order to better represent the system; these changes were suggested during Ward's review for Great Lakes but were incorporated for Great Plains, MZs 39 and 40. No further review for MZs 39 and 40 was obtained (although it was attempted) as this system is just on the outskirts of these mapzones.

This model for MZ41 was largely adopted from the model in MZ51 created by Mike Kost and Jeff Lee who in turn adapted the model from the Rapid Assessment: R6OAHI created 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, 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 and Joshua Cohen.

Vegetation Classes

Class A 3 %

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.

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Class B **14 %**

Mid Development 1 Open

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ 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. Savanna conditions occurred where fire was fairly frequent allowing some trees to develop (5-15yrs). This can also 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. Any area that does not burn frequently would convert to woodland conditions (class C). This was therefore modeled as alternate succession with a time since fire disturbance of 10yrs.

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.

Class C **35 %**

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 0m	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 where fire occurred every 15-25yrs. This class starts at approximately age 15yrs. However, this can also be a steady state expression of this system if fire frequency is high enough. Any area that does not burn frequently would convert to class D. This was therefore modeled as alternate succession with a time since fire disturbance of 20yrs. The canopy closure was <60%.

Overall MFRI is comparable to that in class B: approximately 15-20yrs.

Mixed fire occurs about 50% of the time (half the time returning to B and half the time remaining in C), which is a probability of 0.015 for each.

Surface or low severity fire occurs approximately a third of the time, with no significant effect to the canopy, thus probability of 0.02 remaining in C.

And replacement fire occurs approximately 10% of the time and removes everything, returning to A, thus probability of 0.005.

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Class D 43 %

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. This can be distinguished from class E by species/EVT. The age class is 180-indefinite years as long as fire occurs periodically. If the late-succession open forest type persists for 100yrs 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 40yrs, would maintain this class. Mixed fire, occurs part of the time bringing this class to C (50yrs) or B (100yrs). Replacement fire, modeled at the probability of occurring every 500yrs, would transition class D to class A. Thus the net fire probability is approximately 0.055, such as that for classes A-C. The oaks are going to have a difficult time getting solid regeneration in this class (Curtis 1959) and will need a major canopy opening disturbance to move this to a more open state (C) before they can establish more successfully.

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

☐ Upper layer lifeform differs from dominant lifeform.

Description

MESOPHYTIC FOREST. Maple forests develop during the absence of fire. This class can be distinguished from class D by species/EVT. Dense understories of shade-tolerant species develop. Mixed fires would allow these systems to revert back to oak dominance. Mixed fires, modeled at the probability of occurring every 700-1000yrs, could take the system back to B, C or D; or a replacement fire could take it back to A. Infrequent wind/weather/stress modeled at the probability of occurring every 100yrs would maintain the system in this class. These systems often arise on more moist sites adjacent to or on lee sides of streams, rivers and lakes that serve as fire barriers.

Disturbances

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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	100			0.01	19
Mixed	50			0.02	38
Surface	45			0.02222	43
All Fires	19			0.05222	

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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**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* 3913110** **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** 8/5/2007

Modeler 1	Brendan Ward	bward@fs.fed.us	**Reviewer**	modeler was reviewer
Modeler 2			**Reviewer**	
Modeler 3			**Reviewer**	

Vegetation Type
Forest and Woodland

Map Zone
39

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	QUMA2
QUEL	SAAL5
QUCO2	PRSE2

General Model Sources
☑ Literature
☑ Local Data
☑ Expert Estimate

Geographic Range

This system is found throughout the glaciated regions of the Midwest. Historically, this type was quite extensive in MI, IN, IL, MO, IA, WI and MN.

This system occurs in Province 222. In MI, this system occurs in ECOMAP subsection 222J, and in WI in sections 222K, 222L and 222R.

For MZs 39 and 40, this probably just occurs on the outskirts on the eastern edge of the zone near MN.

Biophysical Site Description

This system can occur on uplands within the prairie matrix or within the context of dry-mesic oak-hickory forests and oak savannas. These are common on rolling glacial moraines and outwash plains. Soils are typically well-drained to excessively drained Mollisols or Allisols that range from sand to sandy loam in texture. It is distinguished from other forested systems within the region by a dry edaphic condition that is transitional between dry prairies, oak barrens, or savannas and dry-mesic oak-hickory forests and woodlands (NatureServe 2007).

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.

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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 MI. 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 and Andropogon gerardii are also common.

In the most acidic lake plain physiographic systems, ericaceous shrubs such as wintergreen (Gualtheria procumbens), lowbush blueberry (Vaccinium angustifolium) and huckleberry (Gaylussacia baccata) become common. Bracken fern (Pteridium aquilinum) can be dominant in the most nutrient poor outwash and lake plain landscapes.

Disturbance Description

Extreme drought, along with periodic ground and crown fire events, constitute the main natural processes for this type and likely maintained a more open canopy structure that supported oak regeneration (NatureServe 2007).

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 and Bowles 1999). These grasslands, deliberately maintained by Native Americans for hunting purposes, were probably scattered throughout the forest matrix. 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. Oak grubs (tree-sprout and shrub thickets) occurred where fire frequency was a bit less, probably 5-10yrs. 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 4-17yrs (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 et al. 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,

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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, woodlands) in presettlement times.

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.

Adjacency or Identification Concerns

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 barrnes. 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 outcompete 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.

Many current examples of this type have resulted from long-term fire suppression and conversion of oak barrens to these forests and woodlands. Fire suppression may also account for examples of this system with the more dry-mesic understory. It likely has allowed for other associates such as Quercus rubra and Fraxinus americana to become more prevalent (NatureServe 2007).

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 effects on understory shade and quick nutrient uptake will exclude the understory intolerant northern pin oak. Implications to forestry, wildlife, and pest and disease outbreaks will become apparent in the future.

This system is distinguished from other forested systems within the region by a dry edaphic condition that is transitional between dry prairies, oak barrens, or savannas and dry-mesic oak-hickory forests and woodlands.

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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 system is also 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.

This might also be difficult to distinguish from BpS 1013 Bur Oak.

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.

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. 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).

Currently, an overabundance of deer is limiting oak regeneration in remnant oak forests in southern MI. 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.

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.

Invasive species, including garlic mustard (Alliaria petiolata), buckthorn (Rhamnus cathartica), and honeysuckle (Lonicera spp.) are becoming increasingly prevalent in the understories of some stands.

Extensive conversion for agriculture in the surrounding landscape with more productive soils has fragmented and isolated examples of this system. It is found primarily within the "corn belt" of the United States, and remaining large areas of this system are likely under considerable pressure due to conversion to pastureland and urban development (NatureServe 2007).

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.

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.

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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

Comments

This model for MZs 39 and 40 was adopted from the model from MZ41 modified by Greg Nowacki and reviewed by Dave Cleland and Brendan Ward. Co-RL, Elena Contreras, for MZs 39 and 40 added information from NatureServe. Quantitative changes to Nowacki's model were made by Brendan Ward in order to better represent the system; these changes were suggested during Ward's review for Great Lakes but were incorporated for Great Plains, MZs 39 and 40. No further review for MZs 39 and 40 was obtained (although it was attempted) as this system is just on the outskirts of these mapzones.

This model for MZ41 was largely adopted from Kost and Lee (5113110) who adopted their model from the Rapid Assessment model, 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 5 %

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 (approximately 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 plus years), 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 33 %

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	0 %	30 %
Height	Tree 0m	Tree 10m
Tree Size Class	Large 21-33"DBH	

- [ ] Upper layer lifeform differs from dominant lifeform.

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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. This was modeled as alternate succession with 30yrs since fire, would bring this class to class D. Replacement fires occurred approximately every 125-150yrs.

Grazing helped maintain the openness of this system.

Wind/weather stress (drought) modeled with a probability of 0.004 (250yrs), returning this class to A.

Class C **47 %**

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 0m	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 <60% but >25%. Woodlands were maintained by surface fire frequency occurring every 25yrs. Mixed fire also occurs every 50yrs, half the time causing a transition back to B and half the time remaining in C. An occasional replacement fire will move this community back to a open grassland stage. If fire is absent from this community for an extended period (e.g., 50yrs - modeled as alternate succession), stand density continues to increase, moving the community to a closed-canopy (60-100%), oak forest (class D).

Class D **10 %**

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. Mixed fire was modeled to occur every 50yrs, bringing this class back to class C, and low severity surface fire every 100yrs. Replacement fire occurred infrequently. During extended period of no fire (65-75yrs since fire), these forests would convert to mesophytic species, class E, 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.

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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
QURU	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). QURU can come in as things trend toward more mesophytic species provided there are canopy gaps from original cohorts of drier oaks. 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.

Disturbances

Fire Regime Group: I**

Historical Fire Size (acres)

Avg 100
Min 10
Max 1000

Sources of Fire Regime Data

- ☑ Literature
- ☐ Local Data
- ☑ Expert Estimate

Fire Intervals

	Avg FI	*Min FI*	*Max FI*	*Probability*	*Percent of All Fires*
Replacement	85			0.01176	16
Mixed	80			0.0125	17
Surface	20			0.05	67
All Fires	13			0.07426	

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)

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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* 3913140** **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

Modeler 1 Becky Schillo schillor@michigan.gov **Reviewer**
Modeler 2 **Reviewer**
Modeler 3 **Reviewer**

Vegetation Type
Forest and Woodland

Map Zone
39

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 ECOMAP subsections 212 Kb, 212 Nb, and 222 Ma, Mb, Mc, and Md. In MZ 50 the BpS would have occurred in subsections 222 Kb, Kc, Kd, Ke, Kf, Kg, Kh, 222 Md and 222 La, Lc, Ld, and Le.

In MZs 39 and 40, this might have occurred as outliers within ECOMAP subsections 251Ba and 251Bb.

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.

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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.

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 yellow birch, black walnut, white ash, white oak, hackberry, butternut, black cherry and Kentucky coffee-tree (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

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.

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.

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 for MZs 39 and 40 was adapted from the draft model from the same BpS from MZs 41 and 50 created by Becky Schillo schillor@michigan.gov and reviewed by Dave Cleland and Brendan Ward. No further review for MZs 39 and 40 was obtained (although it was attempted) as this system is just on the outskirts of these mapzones.

This model for MZs 41 and 50 was 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)

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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
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

This stage is characterized by early-seral young forest following a catastrophic wind or fire event. It is a young forest dominated by aspen, birch, northern red oak, basswood, 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

This stage is 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 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 10.1m	Tree 25m
Tree Size Class	Large 21-33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

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This stage is characterized by late-successional maturing forests (75-150yrs) which succeed to class D. It is a forest dominated by sugar maple, basswood, American elm, ironwood and 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
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 (>150yrs) are the end point of succession. This stage consists of 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 five to ten years 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

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Fire Regime Group:** V

Historical Fire Size (acres)

Avg 5000
Min 10
Max 10000

Sources of Fire Regime Data

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

Fire Intervals	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	1000			0.001	44
Mixed					
Surface	786.5			0.00127	56
All Fires	440			0.00228	

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
- [ ] Other (optional 1)
- [ ] Other (optional 2)

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LANDFIRE Biophysical Setting Model

***Biophysical Setting* 3913310** **Eastern Great Plains Tallgrass Aspen Parkland**

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

General Information

Contributors (also see the Comments field **Date** 4/26/2007

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Vegetation Type
Forest and Woodland

Map Zone
39

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

Dominant Species*

POTR5	COAM3
QUMA2	AMELA
PIBA2	ARLU
SABE2	ANGE

General Model Sources
☑ Literature
☐ Local Data
☐ Expert Estimate

Geographic Range

This system is found primarily on the Glacial Lake Agassiz plain in northwestern MN, ranging into Canada. The main distribution of the system forms an arch from northern MT northeastward along the foothills of the Rocky Mountains in southern Alberta, then curving through central Saskatchewan into southwestern Manitoba and northwest MN. However, the tallgrass portion of the aspen parklands occurs in only a portion of this - from Winnipeg to northwest MN (Archibold 1999 in Anderson et al. eds). In MZ41 the system occurs in ECOMAP subsections 212 Mb and 222 Na. In MZs 39 and 40, this system would have been on the eastern edge in the MN area.

The tallgrass aspen parkland BpS extends roughly from Red Lake Falls, MN to Winnipeg, Manitoba, encompassing 1.2 million acres (Sather and Dana 1999).

Biophysical Site Description

The tallgrass aspen parkland system occurs as an ecotone or transitional community between mixed or tallgrass northern prairie to the south and east and mixed hardwood-conifer forests to the north and west. This community occurs on the shoreline and lakeplain of Glacial Lake Agassiz. This landform is level to gently rolling and featureless.

Soils are sandy with occasional loam deposits. In MN, soils are a complex; Loams predominate, from clay loams to silt loams and sandy loams. Some outwash also occurs in the region, along with sandy soils, the result of a lacustrine sorting process. Clay veneers occur in some areas, and paludification has created many shallow peat deposits, some rather extensive. Soils underlying forested portions of the landscape are

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predominantly sandy.

The climate of the region supporting this community type is cold and dry. The MN DNR reports that the Tallgrass Aspen Parklands Province in northwestern MN has a mean annual precipitation of 20-22in (51-56cm) and minimum temperatures that reach -43C. In this region, evapotranspiration exceeds precipitation with deficits of -2 to -6 inches (MN DNR 2007).

Calcareous glacial drift overlain with lacustrine soils ranging from loamy to gravelly is characteristic of the lakeplain within the range of this system. Historically this system included a mosaic of tallgrass prairie, wet prairie, brush prairie and aspen-oak woodlands (NatureServe 2007).

The tallgrass aspen parkland occupies a very low-relief landscape of smooth ground moraine further subdued during inundation by Glacial Lake Agassiz. Beach ridges formed along longer-lived shorelines of Lake Agassiz are the most prominent topographic features. As a legacy of the period of submergence soils are a complex mosaic of water-modified till (often very stony), sands, silts and clays. Localized sand blankets were formed by outwash or streams draining into the lake and winds have modified some of these into dune formations. Shallow veneers of sedge peat are common in more poorly drained areas (Dana 2000).

Vegetation Description

The tallgrass aspen parkland system is a dynamic matrix system that occurs at the transition from northern prairie to hardwood-conifer forests. The vegetation described here represents the woodland portion of the mosaic and corresponds with the Northwestern Mesic Aspen-Oak Woodland, Minnesota DNR Fire Dependent Forest/Woodland System Type [Minnesota Department of Natural Resources 2007]. Vegetation is also briefly described in the successional class descriptions at the end of this document.

Trembling aspen and balsam poplar are the dominant tree species, and bur oak is usually present, dominating in dry sites and occasional jack pine. Bur oak barrens occupy the driest sites. Woodland patches tend to be small, composed mostly of juvenile trees because of the historically high fire frequency. Abundant shrubs are a striking feature of this community; in the case of the prairie, this results in a distinctive community type, brush-prairie, in which shrubs may form up to 70% of the cover. Rich fen, dominated by fine-leaved sedges, is a common wetland type in the parkland, occurring on moderately decomposed peat. High local concentrations of mineral salts in these peats support an unusual assemblage of plant species.

Paper birch occurs infrequently, mainly in riparian areas. Black spruce, tamarack and northern white cedar occur in small pockets on eastern/northern borders as the transition occurs or the microclimate is favorable. Conifers and paper birch are rare in the MN part of the range , mainly occurring near the transition to eastern forests. The subcanopy is sparse to absent and composed of the same species as the canopy layer.

The shrub layer ranges from 50-100% and may include juneberries (Amelanchier spp.), gray dogwood which is very common, chokecherry (Prunus virginiana) hazlenuts (Corlyus americana, C. cornuta), Bebb's willow (Salix bebbiana), roses (Rosa woodsii, R. blanda) and meadowsweet (Spirea alba).

The dominant tallgrass species is Andropogon gerardii often associated with Sorghastrum nutans, Calamagrostis spp. and Sporobolus heterolepis (NatureServe 2007). Groundlayer varies in cover and also includes grasses and sedges such as mountian ricegrass (Oryzopsis asperifolia), Pennsylvania sedge

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(Carex pensylvania), bluejoint (Calamagrostic canadensis), big bluestem (Andropogon gerardii) fringed brome (Bromus cilliatus), poverty grass (Danthonia spicata) and interrupted wild rye (Elymus diversiglumis). Typical forbs include American vetch (Vicia americana), Canada mayflower (Maianthemum canadense), Lindley's aster (Aster ciliolatus), northern bedstraw (Galium boreale) veiny meadow-rue (Thalicutrum venulosum) tall meadow-rue (Thalicutrum dasycarpum), wild sarsaparilla (Aralia nudicaulis), white sage (Artemisia ludoviciana) and harebell (Campula rotundifolia). (MN DNR 2007, Archibold 1999 in Anderson et al.)

A number of rare or uncommon plants are part of the parkland ecosystem. The hoary fruited willow, Salix maccalliana, is common in the MN parkland but quite rare elsewhere in the state. A major population of the western white-fringed orchid, Platanthera praeclara, occurs in Manitoba with a smaller satellite population a few miles south in MN. The sedge Carex garberi, known from only a single record in MN outside the parkland, occurs in some abundance in rich fens here (Dana 2000).

Disturbance Description

Fire is the most important natural dynamic in this system and helps maintain the open parkland or brush nature of this system. Wind and grazing are also important dynamics (NatureServe 2007). Most generally described, this system is a mosaic of prairie and aspen woodland where drought and fire are frequent enough to prevent succession to forest but not so frequent as to eliminate trees altogether (Dana 2000).

Tree and shrub establishment in this community is limited by climatic factors such as severe cold, low precipitation, summer drought, and desiccating westerly winds from the Great Plains. These climatic variables, combined with the level topography of the Glacial Lake Agassiz lake plain, create a fire-prone landscape that historically experienced frequent fires. An analysis of Public Land Survey records conducted by the Minnesota Department of Natural Resources indicates that catastrophic fires occurred with an approximate return interval of 90yrs. The 90yr interval was questioned by some reviewers, based on the relatively young age of existing aspen following nearly a century of fire suppression. Some of the oldest trees are the smallest oaks in the sand prairies. The life span of aspen in MN ranges from 70-100yrs. Many are under 90yrs, and older trees are almost always associated with settlement (farmstead, church, cemetery, etc. where they were protected). Severe fires were probably more common, while moderate and low intensity fires were very common.

Moderate surface fires are thought to have a return interval of 15yrs, and an all fire return interval of approximately 10-15yrs. Catastrophic windthrow was estimated at a 290yr return interval (MNDNR 2007). Due to model review, these intervals were lowered. The land survey notes and bearing tree data for Kittson Co. suggest that there was very little forest at that time—the descriptions for wooded areas repeatedly refer to “burnt-over aspen” or the equivalent. The distances to bearing trees, and their diameters at breast height, are consistent with frequent disturbance (Robert Dana, pers comm.).

Woody vegetation regenerates quickly following stand-replacing fires. Fire generally does not destroy roots, and aspen suckers, oak grubs, and shrubs survive and resprout immediately. By the second year following a fire, the vegetation resembles a shrub thicket more than a grassland. Several years of fire in quick succession are required to suppress the woody component such that herbaceous species dominate.

Grazing by large herbivores such as bison and elk also might have influenced vegetation patterns across the landscape, restricting tree and shrub establishment and promoting prairie regeneration and the regeneration of aspen suckers.

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Elk were likely one of the major historic TAP herbivores. Over-hunting in the late 1800's, combined with agricultural development, may have decimated herds so greatly that the species was extirpated from the area. Local habitat characteristics suggest that elk and moose may have been the major ungulates of the Tallgrass Aspen Parkland prior to European settlement, with bison making occasional forays into the area from the open prairie of the Red River Valley (Hamel et al. 2006).

Adjacency or Identification Concerns

It is the northernmost expression of the transition between tallgrass prairie and forest ecosystems. In MN it is sandwiched between the conifer forests and peatlands north of Red Lake and the croplands in the former rich prairies of the Red River valley (Sather and Dana 1999). In the MN part of the range, the prairie is west, the forest east of the parkland. This BpS is part a matrix system that would include or be adjacent to 1420 Northern Tallgrass Prairie, 1421 Central Tallgrass Prairie, and 1488 Eastern Great Plains Wet Meadow, Prairie, and Marsh.

Large portions of the aspen parkland have been converted to agricultural land for wheat and barley, small grains, corn and soybean production. Other areas have been seeded within pasture grasses for grazing purposes (Archibold 1999 in Anderson et. al).

Additionally, the removal of large grazers such as bison might have altered the dynamics of the aspen parkland system, particularly the grassland portions of this system. However, this statement was questioned by a reviewer, as there is currently plenty of grazing with cattle, and bison may not have influenced this region the way they did the mixedgrass and sandhills regions of the Great Plains. Elk were a common and permanent part of the grazing/browsing in Tallgrass Aspen Parklands.

Conversion to agriculture and fire suppression have decreased the range of this system and allowed more shrubs and trees to establish (NatureServe 2007).

Incompatible grazing practices also occur in this system.

All of the successional classes would be constantly shifting with drought, high precipitation, fire and grazing. Tree canopy ranges from 25-75% currently but not historically. There has been encroachment currently with fire suppression.

There would be more mature, dense forest than there was historically, although how much is difficult to say. "Since settlement of the TAP area by Europeans, the fire regime of the landscape has been altered. Fires have been reduced in size, frequency and intensity, contributing to encroachment by aspen of the prairie and oak savanna communities. Other factors may have contributed to this trend, such as climate changes and the extirpation of major grazers, such as bison (Campbell and Campbell 2000). What was once an open prairie dotted with oak savannas and small clones of aspen is changing to an aspen forest with sporadic patches of tallgrass prairie and savanna. In a quick analysis of conservation lands within ten randomly selected subsections of eastern Kittson County, Hamel (2004) compared current conditions with those of the original land survey and found that on conservation lands aspen woodlands have increased in cover by 75% over the last century. More thorough analyses are needed to determine a range of variability for the target condition, but the message is clear: land managers need effective management tools to reverse aspen encroachment in the TAP." (Hamel et al. 2006)

Of all the threats to this system, exotics were rated "low," especially compared to altered fire regimes and hydro regimes. "Some degree of invasion by alien and aggressive native species can be found in portions

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of all TAP communities. Without continued, and perhaps intensified, control efforts these species have the potential to rapidly expand across the landscape and seriously degrade natural areas. In addition to directly reducing native biodiversity, plant invasions can alter key local and landscape-scale ecological processes such as fire (e.g. Brooks et al. 2004). The most affected system is the riparian portion of the rivers and riparian system. Increased exposure to invasive species from adjacent agricultural lands, combined with regular disturbance due to flooding and increased subcanopy light levels due to the decline of diseased American elm has allowed invasive species such as burdock (Arctium lappa) to dominate at many locations (TAP Planning Team observations). Dense stands of reed canary grass dominate many streambanks, especially in disturbed areas. In the upland mosaic, leafy spurge and St. John's wort (Hypericum perforatum) have the potential to spread and disrupt large portions of the landscape. At the Manitoba Tall Grass Prairie Preserve, leafy spurge is present at about 50 locations, with new patches appearing each year and increasing in area about five percent per year (Laura Reeves, Manitoba Tall Grass Prairie Preserve, pers. comm.).

Other upland exotics such as red top grass (Agrostis stolonifera) increase due to disturbance and/or overgrazing but decline with proper management. Spotted knapweed (Centaurea maculosa) and birdsfoot trefoil (Lotus corniculatus) are additional species of concern in upland areas. Spotted knapweed seeds are readily transported in hay and on vehicle undercarriages and can remain viable in the soil for up to five years (Lym and Zollinger 1992). The species has been known to remain in confined areas for several years and then rapidly spread to adjoining areas (ibid.). Widely planted as a forage crop, birdsfoot trefoil has spread to many of the TAP's roadsides and trails and has invaded the edges of some native upland sites. The species tends to establish dense colonies that exclude other species. The invasion of beach ridge and lake plain wetlands by reed canary grass and purple loosestrife is currently limited. Where invasions occur, they tend to occur in roadsides adjacent to wetlands, or at wetland edges" (Hamel et al. 2006).

Similar Ecological Systems:
• Northwestern Great Plains Aspen Forest and Parkland (CES303.681)-- biogeography and understory species separate. NW Great Plains system has a more mixed understory with Stipa, Bouteloua and Festuca. Festuca would be a good differential genus.

Adjacent Ecological Systems:
• Northern Tallgrass Prairie (CES205.686)
• Northwestern Great Plains Aspen Forest and Parkland (CES303.681)

Native Uncharacteristic Conditions

Scale Description

This community type is part of a matrix system that would include northern tallgrass prairie, wet prairie, brush prairie and aspen-oak woodland.

The parkland ecosystem is expressed only on a fairly large scale in continuous blocks of hundreds, or better, of thousands of acres (Dana 2000).

Issues/Problems

Comments

This model for MZs 39 and 40 was adapted from the draft model from the same BpS from MZ41 created from scratch by Becky Schillo. Co-Regional Lead for MZs 39 and 40 added some descriptive info. Reviewers Reisz, Dana and Cornett reviewed the system for MZs 39, 40 and 41 together. Therefore, their

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names were added as modelers and reviewers.

Vegetation Classes

Class A 15 %

Early Development 1 All Structure

Upper Layer Lifeform

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

Fuel Model

Indicator Species* and Canopy Position

CAST36	Lower
CACA4	Lower
ORAS	Lower
CAPE6	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

This is the wetter, grass stage with little shrub component and mostly sedge.

This class represents a tall grass (with only occasional mixedgrass prairie grasses) stage dominated by grasses, sedges, and forbs such as big bluestem, bluejoint, Pennsylvania sedge, Mountain rice grass, white sage, harebell and alumroot. Andropogon gerardii is not prominent in this community, and after a fire Calamagrostis canadensis (and often C. stricta, which is hard to even detect before a fire) and Schizachne purpurascans are commonly the most apparent graminoids, though Oryzopsis is common, just not as tall. Often it is forbs that are the most abundant herbaceous species—Aster ciliolatus especially, along with Fragaria virginiana, Thalictrum spp., Solidago canadensis, Aralia nudicaulis and Sanicula marilandica. Alum root is rather rare.

This class would result from class C following a catastrophic disturbance such as a replacement fire or wind event. Otherwise, this class has a prairie disturbance regime where the replacement fires are frequent due to fire, grazing and changing of the seasons.

This class would be maintained by low, moderate and high surface fire (modeled as a replacement fire with the probability of occurring every 5-10yrs as it would result in greater than 75% top-kill) - similar to the adjacent tallgrass prairie - and native grazing (modeled with the probability of occurring every 5 years (0.2)) by bison and elk. Severe drought, modeled as wind/weather/stress with a probability of occurring every 100yrs (0.01), would also limit tree and shrub establishment and maintain this class.

This class lasts is set to last from 0-3yrs, the estimated time it would take for shrubs to become the dominant lifeform, although they are still present in this stage. Shrubs and aspen suckers would most likely establish during this stage if there is a nearby seed source or aspen grove. However, shrubs are nearly always a component as aspen establishes. It is noted, however, that woody vegetation instantly is an important component following a fire. Aspen suckers, oak grubs and shrubs survive and resprout immediately. Note that it would take a long time for prairie species to reinvade an area that had developed to this forest type if somehow fire would become frequent enough to prevent the regrowth of the forest. The situation would be different for areas that were open woodland—the prairie grasses, etc., are usually fairly common in these, and stand-removing fire results in a luxuriant growth of these.

Class A, a wetland with little shrub component and mostly sedge, would probably have encompassed 15-20% of the landscape. Class A combined with class B (prairie and brush prairie communities) encompassed probably approximately 60-70% of the historical landscape.

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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 **60 %**

Mid Development 1 All Structures

Upper Layer Lifeform

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

Fuel Model

Description

Indicator Species* and Canopy Position

COAM3	Low-Mid
COCO6	Low-Mid
SABE2	Low-Mid
POTR5	Lower

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	100 %
Height	Shrub 0m	Shrub 1.0m
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform.

Co-RL for MZs 39 and 40 questioned whether or not the cover would go all the way up to 100% Tree cover might also be 0-5m up to 20% cover.

This class represents a brush prairie stage dominated by shrubs such as willows, American and beaked hazelnut, chokecherry, juneberry, viburnum, rose and poison-ivy. Young aspens and oaks would also be present in this class.

This is a prairie/brush prairie (wet/dry) and oak savanna maintained by fairly frequent fires of varying intensity. Oaks might also be an indicator species.

As microclimates, climate and disturbance allow, aspen establishes and/or encroaches, especially from established clones and around wetlands. These small trees are seen in this class. They take 10-15yrs to establish, and the older they are, the more intense the fire needs to be.

Replacement fires would occur and would change stature but wouldn't revert the class back to class A with just one fire. It would take 3-5 replacement fires in a 10-15yr period to revert this class back to class A. Since percentage probabilities cannot be modeled in LF, this was converted to an approximate every 40yrs this would occur. However, it is noted that even such an event would still leave some shrubs reduced in stature and less abundant. Woody vegetation instantly is an important component following a stand-destroying fire. The fire does not detroy the roots of most, and aspen suckers, oak grubs, and shrubs survive and resprout immediately. By the second year following fire, the vegetation is more like a shrub thicket than a grassland. It takes several years of fires in quick succession to push the woody component down relative to the herbaceous.

Low severity or surface fire, modeled with the probability of occurring every six years, would maintain the system in class B. A low intensity surface fire will not topkill 10-15yr old aspen. The other shrub species (willow, birch and hazel) do not seem to behave this way.

Drought occurs, modeled with the probability of occurring every 100yrs and not causing a transition.

This class is set to range from 4-19yrs and succeeds to class C.

For this class combined with class A encompassing the open sedge, prairie and brush prairie communities and classes, they both encompassed probably approximately 60-70% of the historical landscape. This class B itself as the prairie/brush prairie and oak savanna would encompass approximately 55-65% of the landscape.

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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 C **25 %**

Late Development 1 All Structures

Indicator Species* and Canopy Position

POTR5	Upper
QUMA2	Upper
PIBA2	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	50 %
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

This class represents a woodland stage with a patchy canopy of trembling aspen with bur oak; there are a very few areas of jack pine and white spruce associates.

Large, mature aspen would occur in this stage, but even these are not the dense forests we often see now, but rather more open woodland with herbaceous and shrub layers. They seemed to be small in size with large mature trees of the clone radiating out with suckers and trees of dwindling stature. These trees are fairly short-lived and individuals seldom reach over 60yrs today. The clone, on the other hand, can have a very long life.

Fire can also set this class back to a form of class B or maintain this class C. This was modeled as replacement fire half the time causing a transition to B, and surface fire half the time maintaining this stage, occurring with an overall interval of six years. This replacement fire is modeled as setting this stage back to B and not A because the regen on aspen is almost immediate, and three foot saplings the growing season following a fire are common. These will often be more abundant than would be found at the encroachment zone and would have much more energy in the root reserves from which to draw. After a stand replacement fire in aspen or willow, there is immediate regrowth often with increased stem density. It would take multiple fires at short intervals to set things back to the grass shrubs. Replacement fires would occur and would change stature but wouldn't revert the class back to class A with just one fire. It would take 3-5 replacement fires in a 10-15yr period to revert this class back to class A. Since percentage probabilities cannot be modeled in LANDFIRE, this was converted to an approximate every 40yrs this type of replacement fire would occur. However, it is noted that even such an event would still leave some shrubs reduced in stature and less abundant.

Oaks are very difficult to set back, and they were probably fairly abundant here. There were probably quite a few scattered savannas and open woodlands while aspen clones were smaller in size and much more likely to shift due to disturbance over a shorter timeframe.

Catastrophic wind, modeled as wind/weather/stress with the probability of occurring every 300yrs, would set the system back to class A. Drought, modeled as wind/weather/stress would also maintain this system in this class although it could also lead to some aspen die-back.

(Some felt that Insect/disease such as a canker fungus could infect an entire aspen grove; however this was questioned by review and therefore removed from the model).

This class would range from 16-999yrs. However, it is thought that aspen would hardly reach 70yrs before die-off. However, oaks might persist.

The GLO and historical references indicate few trees, most small and stunted; therefore, it is thought that this

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stage would occupy approximately 15-30% of the landscape historically, although it might occupy more currently due to encroachment.

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: I**

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			0.06667	40
Mixed					
Surface	10			0.1	60
All Fires	6			0.16668	

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 3913651 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

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

Modeler 1	Peggy Burkman peggy_burkman@nps.gov	**Reviewer**	n/a
Modeler 2		**Reviewer**	
Modeler 3		**Reviewer**	

Vegetation Type

Forest and Woodland

Map Zone

39

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 Alaska. 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 km of the Great Lakes shorelines. This is due primarily to one km 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 ECOMAP 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 al. 1995, Maycock and Curtis 1960,

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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).

Vegetation Description

This system is 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, Mainthemum canadense, Mitella nuda, Mitchella repens, Pteridium aquilinum,

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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, 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, Maycock and Curtis 1960, Curtis 1959).

Selective browsing by moose in the Upper Peninsula of MI (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

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 1000m of the shoreline and correspond to conifer dominated current land cover.

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

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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 1930's have converted some of this system.

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

More research is needed 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

This model for MZs 39 and 40 was adopted as-is from BpS 1365 from MZ41 created by Peggy Burkman and reviewed by Dave Cleland. No review was obtained for MZs 39 and 40, as we were told of the occurrence of this system at a late date, and it is thought to only occur on the outskirts of this mapzone on the MN edge.

This model for MZ41 was 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

This stage is a 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

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aspen initially dominate over spruce and fir. With time this class succeeds to class C.

This should be distinguished from class B by species/EVT.

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

This is a 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.

This class should be distinguished from class A by species/EVT.

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

This is a mature aspen-birch with spruce-fir-cedar understory development. Class A succeeds to class C and class C succeeds 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

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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 is a 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.

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 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 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)

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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 3913652 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

Modeler 1	Peggy Burkman	peggy_burkman@nps.gov	**Reviewer**
Modeler 2			**Reviewer**
Modeler 3			**Reviewer**

Vegetation Type

Forest and Woodland

Map Zone

39

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 Alaska. 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 km 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 ECOMAP 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, 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).

In MN 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

This system is 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, Harman and Plough 1986, Rutkowski and Stottlemyer 1993, MNFI Database).

Disturbance Description

The natural disturbance regime is characterized by frequent windthrow and insect epidemics, which are typically small-scale events. Choristoneura fumiferana (Spruce budworm) defoliates both spruce and

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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

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. We estimate that the fire return interval for the inland boreal forests of MI 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, Comer et al. 1995).

Selective browsing by moose in the Upper Peninsula of MI (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

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

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 1930's have converted some of this system.

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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**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

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

Issues/Problems

More research is needed 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

This model for MZs 39 and 40 was adopted as-is from BpS 1365 from MZ41 created by Peggy Burkman and reviewed by Dave Cleland. No review was obtained for MZs 39 and 40, as we were told of the occurrence of this system at a late date, and it is thought to only occur on the outskirts of this mapzone on the MN edge.

This model for MZ41 was 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

This is a 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.

This class should be distinguished from class B by species/EVT.

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.

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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

This is a 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 less than 70yrs, this class will succeed to class D.

This class should be distinguished from class A by species/EVT.

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

This is a mature aspen-birch with spruce-fir-cedar understory development. 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

This is a 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.

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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: V**

Historical Fire Size (acres)

Avg 500
Min 100
Max 1000

Sources of Fire Regime Data

- ☑ Literature
- ☐ Local Data
- ☑ 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 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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LANDFIRE Biophysical Setting Model

Biophysical Setting 3913850 Western Great Plains Wooded Draw and Ravine

☑ *This BPS is lumped with: 1085*

☐ *This BPS is split into multiple models:* *There are small patches of shrubs with cutbanks and extra moisture – with chokecherry and juneberry, and snowberry that would have existed historically, but not in large amounts (might be in another system - woody draws, floodplains). Historically, it existed in the upper ends of woody draws and the topographic relief zone that gave shelter. In other words, in the woody draw system, it might have existed in areas dependent on fire breaks or other landscape features that provided more moisture and less frequent or severe fire (Dave Ode, pers comm.).*

Mesic shrubs (snowberry, chokecherry, buffaloberry, etc.) occurred historically, but maybe more as inclusions on more mesic sites (swales, draws, drainageways, north aspect slopes, etc.).

General Information

Contributors (also see the Comments field **Date** 6/1/2007

Modeler 1	Jack Butler	jackbutler@fs.fed.us	**Reviewer**	modeler was reviewer	
Modeler 2			**Reviewer**	Mary Lata	mlata@fs.fed.us
Modeler 3			**Reviewer**		

Vegetation Type

Wetlands/Riparian

Dominant Species*

FRPE	SYOC
ULAM	CASP7
ACNE2	ELYMU
PRVI	QUMA2

General Model Sources

- ☑ Literature
- ☑ Local Data
- ☑ Expert Estimate

Map Zone

39

Model Zone

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

Geographic Range

This system is predominately west of the Missouri River in ND and SD, with minor extensions east of the Missouri River and south into NE. (It also extends into WY and MT.) It occurs in upland draws and ravines scattered throughout the Northern Mixed Grass Prairie and Northern Great Plains Steppe. This BpS is probably best developed in the Little Missouri Badlands of western ND. This BpS also extends along drainages east to the Missouri River, and west and north.

In MZs 39 and 40, it occurs mostly on the western edge, the Missouri River floodplain and extensions that come out. But when it crosses out of the floodplain and into current farmland, it becomes more difficult to determine if it is a woody draw or another system. There might have been some in ECOMAP subsections 331Mc, 331Ea.

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See Adjacency/Identification Concerns box regarding where smaller second and third order prairie streams occur and how they are classified.

Biophysical Site Description

The true wooded draw is a small, mesic island surrounded by upland grasses.

This BpS occurs in major tributaries and upland drainages with extensions onto steep north-facing slopes. The vegetation type is best developed in topographic conditions that favor snow trapment and protection from fires in the adjacent grasslands. It is heavily influenced by topographic situations that produce a combination of deeper soils, supplemental moisture from run-off and snow catchment. Soils on toeslopes and north facing backslopes are deep and well developed, while slopes on south facing backslopes tend to be dry, coarse textured and not well developed.

In Theodore Roosevelt National Park, it occurs in ravines or draws or on moderately steep north-facing slopes throughout much of the Park (Hansen et al. 1984).

Vegetation Description

This system contains an intricate mix of western grassland and shrubland species, with elements of eastern deciduous woodlands. The northern extent occasionally supports quaking aspen, while the southern extent supports Juniper species, and the western extent includes ponderosa pine.

Green ash and chokecherry are dominant species, as well as buffaloberry (buffaloberry might not occur as far east as MZs 39 and 40, however), snowberry and American elm. On the north end into ND, aspen and bur oak would start occurring and paper birch (in Theodore Roosevelt NP; also tend to be small, incidental communities in the Little Missouri NG). In southern extent, those would not be present as much. Rocky Mountain juniper (although it might not occur in MZs 39 and 40) also occurs in places, but tends to be an understory shrub in MT. Canada wildrye and woods rose might also be present. Muhlenbergia racemosa is also common.

Other dominant species: poison ivy

Disturbance Description

The Wooded Draw BpS forms an intimate association with adjacent mixedgrass prairie and shrublands where non-typical-replacement fires are relatively frequent because of productive grass fuels and cycles of moisture and drought. Fires could go through the tree stands without topkill. Most years, the fires occur and meander but they're not intense enough to crown.

The adjacent grassland areas are the greatest source of fires for the woody draw system. However, woody draws play an important role in breaking up the fire frequency and continuity from grassland areas; it influences their extent. Fires can homogenize the area, but the continuity is broken by the woody draws.

There were low intensity fires by Native Americans; they burned when it was more manageable - in the spring. They also used fires for other purposes. In these conditions, woody draws could be an important influence in the distribution and continuity of fires (Jack Butler, USFS, pers comm).

Stand replacement fires were fairly infrequent, otherwise there would have been even-aged stands. Less frequent stand replacement fires were generally associated with periods of exceptionally high moisture conditions immediately followed by severe dry conditions. Mixed fires opened the canopy to allow for different age classes. Low and mixed severity fire probably occurs on average every 10yrs in the

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grasslands. However, the fires probably stopped at the boundaries of the woody draws, since they would be more mesic and greener in this system. Also - the topography would have stopped fire, as draws are more broken and could have therefore been protected by grassland fire (Jack Butler, USFS, pers comm). Therefore, they would be less frequent in the draws.

Deciduous trees in the Badlands of the Dakotas in woody draws are reported to be no older than 50yrs and juniper no older than 100yrs (Warner 1993). The fire return intervals of 15-30yrs were estimated for more broken topography at Scotts Bluff National Monument, NE (Wendtland and Dodd 1992). This return interval would have interacted with long term wet and dry periods for the area. The edges of these draws would have been impacted by the return intervals and fire frequencies of the surrounding prairie. The more mesic areas of the draws would have only been likely to burn in dry periods. The community, when maintained by fire, will have a mosaic of different age classes within a watershed. Browse for ungulates will increase. Sheltering cover will remain within 25% of current levels. Canada thistle and associated non-native species related to homesteading will be reduced. The structural complexity of the community will be maintained (from Badlands National Park Fire Management Plan).

Drought and moist cycles are major factors that interact with both fire and native grazing. This system is dependent on drought in order to have a fire. In drought periods, especially in late fall/summer, conditions were dry enough for stand replacing fires.

The grazing/fire interaction was more pronounced in the east of MZs 39 and 40, because of water sources - bison and ungulates congregated near water during drought, and there were more water sources in the east.

In areas where Rocky Mountain juniper or ponderosa pine invade woody draws, it enhances the flammability of system; fire carries through system. Juniper would then be lost, and smaller pines would be lost.

In some of the woody draws, there is bur oak; since it’s fire-tolerant, a strong sprouter and shade intolerant, it will be enhanced by stand replacing fire, in times with higher moisture. Fraxinus is even more tolerant than bur oak - so it would sprout up too after high intensity fire. Periods with more fires - bur oak dominates. Without fire - elm and ash dominate.

Many of the trees including weak sprouters such as green ash and American elm could be killed by drought and fire together.

There are also probably higher concentrations of ungulates during a drought, since that would be the only area that might still be "green." Therefore, it is an interacting impact of drought and animals. Native ungulates play a role in stand regeneration on sites where deer and elk and bison concentrate for food, cover and shelter. They were good "lounging" areas for native ungulates.

Heart rot can occur with Fraxinus spp.

Adjacency or Identification Concerns

This system occurs in upland draws and ravines scattered throughout the Northern Mixedgrass prairie. There may be intermediates of this type of green ash communities and cottonwood stands, especially in the eastern portion of the mapzone along the larger, primary drainages associated with the Missouri River, and also in southern edge of Black Hills. In some cases, the type merges with north-facing Rocky

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Mountain juniper stands, especially at the top of draws.

This system would be adjacent to BpS 1132 and 1141. With the right conditions and a break in these systems, BpS 1385 will occur.

In the eastern part of MZs 39 and 40, there are more riparian systems instead of woody draw/ravine systems. The topographic situations become less important moving east, because the precipitation is increasing. The true wooded draw is a small, mesic island surrounded by upland grasses. Moving east, it develops more into an overall woodland system - i.e.: streambank, creek, more riparian, more gallery forests. In the middle of MZs 39 and 40, there are more permanent and more mesic systems. The woody draws are more smaller extent, narrow fingers associated with drainages and upland depressions - around badlands type topography - versus going east.

Much of the area of this system is now farmed and are shelterbelts in the east of MZs 39 and 40, whereas in the west it has since regenerated.

This system could also grade into the Floodplains or riparian areas. There might be some difficulty distinguishing the Floodplain Systems from the Riparian from the Wooded Draw/Ravines - and where to assign smaller, second and third order prairie streams. The second and third order prairie streams can sometimes have cottonwood and be like small rivers (Riparian, Floodplain); sometimes they are dominated by other woodies such as water birch, boxelder, green ash (Wooded Draw/Ravine) and willows, depending on how far east one goes; sometimes they have very few woody plants other than silver sagebrush. Streams in the eastern half of MT (east of the Big Snowies) could probably be modeled as either a cottonwood successional sequence or a woody draw successional sequence, depending on the size of the drainage basin. If the basin is large enough there will eventually be a flood big enough to result in cottonwood regeneration. This may not happen very often naturally, so these types of drainages would be in silver sagebrush a lot of the time. This is especially true now that there are not all the impoundments in the headwaters of these prairie streams. Drainages that just don't have the area to get a good flood would probably have been some sort of woody draw, dominated by green ash in the eastern third of the state or other woodies like hawthorn or chokecherry in the more western part of the Great Plains. In terms of assigning the drainage to one or the other type of system would depend on basin size.

Eastern red cedar might be moving into the east of MZs 39 and 40, as well as Russian olive. Kentucky bluegrass has taken over in grazed sites, and leafy spurge is dominant in the Little Missouri grasslands.

The invasion of Rocky Mountain juniper also goes into the upper reaches on north facing slopes. There has been an invasion of juniper out of the woody draws into the grasslands. It's a large problem in NE and an increasing problem in SD. Juniper would have occurred historically in the woody draws and Missouri River Breaks. Now it's encroaching and spreading throughout - since it's also being planted for shelterbelts. So there are seed sources now everywhere invading grasslands from TX to Canada.

There has also been a substantial reduction currently in regeneration - green ash, box elder, elm and shrubs, and there is an increase in grazing-resistant species and thorny species.

There is a lot of farming, ranching and intense agriculture in MZs 39 and 40.

Grazing by domestic livestock has reduced regeneration (increased mortality). On heavily grazed sites, stands are much more open than historically, with an understory of Kentucky bluegrass. There's also more

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compaction. Mid-story and regeneration is "missing." Then trees start getting decadent, so can lose the whole stand. Combo of drought and grazing/trampling could cause loss of stand.

There's probably less of this system currently versus historically. Due to grazing, this system probably appears departed from its reference condition. Where this system is located, its extent is reduced. So now - there are smaller remnants. They haven't completely been converted; they are shrunken and more restricted in areas. The distribution might be okay, but maybe only the central area of the draw is there now. Currently, there is farming right up to the banks of the draws in MZs 39 and 40.

In many of the woody draws on Buffalo Gap and Oglala NGs, cattle will hang out in the draws and prevent almost all surface vegetation from growing. This increases erosion, compacts soil and affect flammability for those fires that do occur. This leads to an overabundance of Rocky Mountain Juniper in some draws. Fires burning up these draws with good burning conditions would be high severity (take out everything aboveground).

Some have questioned, during review of lumping of 1085 Northwestern Great Plains Shrubland, where snowberry, chokecherry and other mesic shrubs occur in draws and drainageways, are they early seral to tree dominated woody draws in the absence of fire or a change to longer fire intervals.

Native Uncharacteristic Conditions

There is less regeneration and less open canopy conditions today.

Scale Description

Western stands are usually relatively small (<50ac). Larger areas, 50-100ac, occur infrequently on the eastern and northern edge of distribution. Long, linear corridors could be <50m wide but snake through the landscape for many miles, although it is not necessarily a continuious system (dendritic scale similar to riparian scale).

Most fires meander from adjacent system - grasslands. If it’s a drier year, fires will burn through system.

Issues/Problems

There is a lack of research on MFRI in this system.

The long, linear nature of this system’s distribution makes it difficult to map. Consequently, they are often listed as a complex in relatively small-scale mapping efforts.

Comments

This model for MZs 31, 39, 40 was adapted from the model from the same BpS from MZs 30 and 29 created by Jack Butler and Lee Blaschke and reviewed by Carolyn Hull-Sieg, Mary Lata and Linda Vance. Model changed slightly quantitatively due to refinement of model and some changes moving east.

This model for MZ 29 and 30 was adapted from the model from Rapid Assessment R4WODR created by Jack Butler and Stefanie Wacker and reviewed by John Ortmann; however, portions of the MZs 29 and 30 model were also taken from MZ20 model for this BpS created by Peter Lesica. The VDDT model and descriptions used were those from MZ20.

This model for MZ20 was adapted from the Rapid Assessment model R4WODR Northern Great Plains Wooded Draws and Ravines created by Jack Butler and Stefanie Wacker and reviewed by John Ortmann.

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For MZ20, major descriptive and quantitative changes were made in order to represent MT better. The MZ20 model was changed to a three-box model.

Vegetation Classes

Class A 16 %

Early Development 1 All Structure

Upper Layer Lifeform

- ☐ Herbaceous
- ☑ Shrub
- ☐ Tree

Fuel Model

Indicator Species* and Canopy Position

CASP7	Lower
SYOC	Upper
PRVI	Upper
	Lower

Structure Data (for upper layer lifeform)

	Min	Max
Cover	21 %	80 %
Height	Shrub 0m	Shrub 1.0m
Tree Size Class		

☐ Upper layer lifeform differs from dominant lifeform.

Description

This class is dominated by shrubs for most of the class, although grasses are present too. Cover averages approximately 50%, and the minimum cover would never be as low as 0%. In the first year, herbaceous species might dominate. The herbaceous cover is high underneath the shrubs. The herbaceous cover would probably be 25-50% cover. This class succeeds to B after approximately 10-30yrs. The 10yr interval would have to involve fairly favorable conditions. With wet/dry cycles, there would need to be the right combination. On the eastern edge of MZs 39 and 40, however, 10yrs is probably more likely, but on the western edge of MZs 39 and 40, 30yrs is more likely.

This class is similar to a snowberry rose coulee type. It contains chokecherry and snowberry, with a mesic understory of CASP7 and various woodland forbs and poison ivy.

The transition from A to B could be retarded by native ungulate browsing. Grazing could set this stage back to its beginning state, although it was not modeled as such. Grazing, however, is dependent on weather cycles, as well. However, deer select green ash. There is also elk browsing.

The combined effect of drought and grazing was modeled as Optional 1. It was modeled to occur on 10% of this class on the landscape each year, or every 10yrs. This might be more pronounced moving further east. Further west, the distribution of animals is controlled by permanent water sources. During drought, the grazing is more concentrated near water. In west, grazing is less pronounced because there is less water nearby. The systems that are closest to permanent sources of water, probably are more impacted.

Grazing alone was modeled as occurring on 35% of the landscape each year.

The MFRIs are similar to grassland systems, but we're not in a grassland system here the entire 20yrs or throughout the system - partly shrubs, so there aren't replacement fires occurring all of the time. Occassionally, there are replacement fires if going through the grass. There are also mixed severity fires - 25-75% topkill - since the shrubs aren't completely topkilled. Fires were modeled at an overall interval of 15yrs, half replacement and half mixed severity. Fire is more frequent in this stage than in classes B or C, because grassland is adjacent.

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Class B 29 %

Mid Development 1 All Structures

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

PRVI	Mid-Upper
SYOC	Low-Mid
FRPE	Lower
CASP7	Low-Mid

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	11 %	50 %
Height	Tree 0m	Tree 5m
Tree Size Class	Sapling >4.5ft; <5"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

This class is dominated by shrubs and trees and is a mid-development stage. Its ages are 20-29yrs. As the community develops, the microclimate changes. So - once the seeds, shrubs and trees are there, it changes the microclimatic conditions. The microclimate is more prominent in class B than class A, so this allows a quicker transition to C. Trees are coming in and getting taller in this stage. Trees are growing approximately 2/3 of a foot each year. A 30% canopy cover of trees would be the average (Lesica 2001). This stage reaches approximately 30yrs of age. It is similar to class A, but the shrubs are taller, and the trees that are coming in, are beginning to overtop the shrubs. A true tree canopy has not yet developed.

The MFRI is similar to that in a grassland system, although this system might experience somewhat less frequent intervals, as occassionally fires might not burn through this stage. Some will be replacement fires (100yrs) and take out all of the stand, although this would be less frequent and would also depend on the year and drought. Some fires might maintain the stand. Most of the fires would be mixed (40yrs) and low severity (65yrs), although the frequency of types would be similar. There would be less mortality on larger trees. During episodes of drought and grazing, there would be no fuels present for fire. Fire was therefore modeled at an overall frequency of 20yrs, but split 30/50/20 percent between low, mixed and replacement fires. The low and mixed fires do not cause a transition to another stage.

The combined effect of drought and grazing was modeled to occur on 10% of this class on the landscape each year, but not causing a transition, and rather maintaining this class. Native grazing was modeled to occur on 25% of the class each year (or affecting the whole class every four years).

Class C 55 %

Late Development 1 All Structures

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

FRPE	Upper
PRVI	Mid-Upper
SYOC	Middle
CASP7	Lower

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	31 %	100 %
Height	Tree 5.1m	Tree 10m
Tree Size Class	Large 21-33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

This class begins at approximately 30yrs old and persists. This includes both open and closed stages of this system in this age range. An average canopy closure would be approximately 50%. Height can be between 40-70ft and DBH approximately 45in (USDA FS 2002), although most old-mature ash trees in this type in MT are 20-40ft high with a basal diameter of 20-30in. Tree canopy in this stage is now formed. It takes on aspects of a woodland instead of a shrubland (the first two classes are more shrub communities).

In this well developed mature class, there is not much ladder fuel. As it moves towards closed canopy situation, there is less understory vegetation and less continuity for a fire to move through. While it is open,

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there would be more grass fuels. Low severity fires don't really get into the woody draws except on the edges or peripheral areas and would be difficult to measure in this class and would probably be inconsequential; therefore, they were not included in the model. In this class, there would have to be a lot of biomass and the right conditions to have a replacement fire; ladder fuels would have to be present. Replacement fire was therefore modeled with a 100yr interval. It's possible that perhaps if there were successive grass fires, there would be enough buildup that would eventually cause a replacement fire. There would have to be high biomass followed by hot, dry conditions.

The combined effect of drought and grazing was modeled to occur on 10% of this class on the landscape each year, but not causing a transition, and rather maintaining this class.

Disease might occur in this stage, which opens the stand (Lesica et al. 2003). In MT, this is more prominent than in the Dakotas. In the Dakotas, canopy closure could be 90%. In MT, open canopy would be about 40-45%, and the relatively open nature of stands is probably due, in large part, to high rates of heart-rot disease. Disease is not as common further east, in the Dakotas, NE, etc, and as one gets further east into higher precipitation zones. In the east, canopy cover would be higher and more closed (therefore, canopy cover increased to 100% for MZ29/30). Disease was therefore not modeled for MZs 39 and 40.

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

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Fire Regime Group:** I

Historical Fire Size (acres)

Avg 50
Min 5
Max 100

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	90	30	100	0.01111	36
Mixed	65			0.01538	50
Surface	220	10	225	0.00455	15
All Fires	32			0.03104	

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] Native Grazing
- [x] Other (optional 1) grazing and drought together
- [ ] Wind/Weather/Stress
- [ ] Competition
- [ ] Other (optional 2)

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LANDFIRE Biophysical Setting Model

Biophysical Setting 3913940 North-Central Interior Oak Savanna

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

General Information

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Vegetation Type

Upland Savannah/Shrub Steppe

Map Zone

39

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 Ohio, 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 11-13 million ha (27-32 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 MI

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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 10-60% 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 MI, 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 1991). 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 1960, Curtis 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 (BpS 1310) and North-Central Interior Dry Oak Forest and Woodland (BpS 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 ECOMAP sections 222K and 222R. This type can also intergrade with North-Central Oak Barrens (BpS 1395) as soils become increasingly sandy. In 222L it is also associated with moderate levels of silt. In ECOMPA sections 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

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regeneration of oaks and a vanishing graminoid component (Chapman et al. 1995). With the absence of 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

Replaced original 13940 model for this zone with this one as per suggestion of Brendan Ward to address problems we've had with this particular model in previous zones. Changed probability of mixed fire in class D from 500yrs to 40yrs because of the way surface fire was maintaining system in class E in LANDSUM (about 40-50% of relative cover) as opposed to disturbance resetting to a more open state (M.H. Weber at MFSL 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.

This model was updated on 10/24/2007 by Randy Swaty to lump classes D and E.

Comments

This model for MZs 41, 50 and 51 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, and Donald Dickman dickman1@msu.edu. Micheal Kost, Nancy Braker and Christopher Weber made substantial descriptive or quantitative changes to the aforementioned Rapid Assessment model resulting in a change in modelership. For this LANDFIRE model, 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

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Class A 21 %

Early Development 1 All Structure

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 3

Indicator Species* and Canopy Position

ANGE	Low-Mid
SCHIZ4	Low-Mid
QUMA2	Upper
POTR5	Upper

Structure Data (for upper layer lifeform)

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

☑ Upper layer lifeform differs from dominant lifeform.

Herbs, up to one meter tall, ranging in cover from 0-100%, tending towards 100%.

Description

0-50yr old class consisting of prairie grasses and forbs which dominate open grassland with scattered oak grubs and clumps of shrubs. These grubs can become trees in this class, but are fairly scattered.

There are a number of replacement distrubances that cause a return to this class: mixed fire (100yrs, 0.01 probability), replacement fire (200yrs, 0.005 probability), surface fire (every five years, 0.2 probability) and wind/weather/stress (drought or tornado, every 1000yrs, 0.001 probability).

So that the distrubances keep this class cylcling as intended, this class succeeds to itsself and transitions to other classes are obtained using alternative succession in VDDT. If a pixel has not experienced a distrubance with a probability of 0.001, it will move to either class C or D. This is a rare event in this system.

Class B 57 %

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	Middle

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 (21-60% canopy closure). Class age begins at 51yrs and is set in VDDT to end at 999yrs.

Disturbances in this class include mixed fires, which can send this class to class A (200yrs, 0.005 probability), and replacement fires that can reset the system to class A (700-100yrs, 0.001 probability). Three distrubances are captured that maintain the class in B: rare native grazing (700-1000yrs, 0.001 probability), surface fire (five years, 0.2000 probability) and wind/weather/stress (700-1000yrs, 0.001 probability).

This class is set to succeed to itself, moving to box C with alternative succession in VDDT with a time since disturbance of 25yrs. This suggests that if this box does not experience a fire disturbance for 25yrs, it will succeed to box C.

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Class C **12 %**

Late Development 2 Open

Indicator Species* and Canopy Position

QUAL	Upper
QUMA2	Upper
QUVE	Lower
	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.

Upper Layer Lifeform

☐ Herbaceous
☐ Shrub
☑ Tree

Fuel Model 3

Description

Open canopy (60-80% canopy closure) oak-dominated woodland with high stem density. These oak groves occupy areas of the landscape that frequently escape fire due to topographic position. Class age begins at 51yrs and is set in VDDT to end at 999yrs.

Native grazing (700-100yrs, probability 0.001) and surface fires (five years, probability 0.200) keep this box in C, mixed fire (500yrs, probability 0.002) moved these pixels to class B and replacement fires (700-100yrs, probability 0.001) can send the pixels to class A. Wind/weather/stress (700-100yrs, 0.001 probability) send the pixels to class A.

This class is set to succeed to itself, moving to box D with alternative succession in VDDT with a time since disturbance of 25yrs. This suggests that if this box does not experience a fire disturbance for 30yrs, it will succeed to box D.

Class D **10 %**

Late Development 3 Closed

Indicator Species* and Canopy Position

QUAL	Upper
QUMA2	Upper
CAOV2	Upper
PRSE2	Low-Mid

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.

Upper Layer Lifeform

☐ Herbaceous
☐ Shrub
☑ Tree

Fuel Model 8

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. Class age begins at 51yrs and is set in VDDT to end at 999yrs.

Native grazing (700-100yrs, probability 0.001) and surface fires (10yrs, probability 0.100) keep this box in D, mixed fire (changed to 40yrs - original model est. at 500yrs but in LANDSUM WAY too much in class D) would send the system back to class B and replacement fires (700-100yrs, probability 0.001) can send the pixels to class A. Wind/weather/stress (700-100yrs, 0.001 prbability) send the pixels to class A.

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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 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	50			0.02	9
Mixed	180			0.00556	2
Surface	5			0.2	89
All Fires	4			0.22556	

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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LANDFIRE Biophysical Setting Model

Biophysical Setting 3913950 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

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Vegetation Type

Upland Savannah/Shrub Steppe

Map Zone

39

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 Ohio, northern IN, northeastern IL, southern WI, and southeastern to northwestern MN. The system is found in ECOMAP subsections: 222J:b, h, g, c.

For MZs 39 and 40, this might occur on just the eastern edges.

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 (Michigan Natural Features Inventory 1990, Chapman et al. 1995). In general, oak barrens are most prevalent on the western side of major firebreaks such as rivers (Curtis 1959, Grimm 1984, Leitner et al. 1991). In the 1800s, the oak savanna communities (e.g., oak barrens, oak openings and oak savannas) covered some 11-13 million ha (27-32 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

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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 (Michigan Natural Features Inventory 1990, Bowles and McBride 1994, Chapman et al. 1995). 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. 1989) 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 MI, Rhus copalina (shining sumac), 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

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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 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 type includes the following ecological systems: North-Central Interior Oak Savanna (CES202.698) and North-Central Oak Barrens (CES202.727).

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

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.

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Comments

This model for MZs 39 and 40 was adapted from the draft model from the same BpS from MZs 41, 50 and 51 created by Michael Kost, Nancy Brakar and Chris Weber, and reviewed by Robert Dana and Dave Cleland. Robert Dana reviewed for MN, including MZs 39, 40 and 41.

This model for the Great Lakes mapzones 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,s50 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 9 %

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	51 %	100 %
Height	Herb 0m	Herb >1.1m
Tree Size Class	Seedling <4.5ft	

- [ ] Upper layer lifeform differs from dominant lifeform.

Description

This class consists of 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) 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 19 %

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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This consists of 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 **64 %**

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 51yrs+. A mixed fire (est. at a 200yr probability) would send the system back to class B. A replacement fire (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 **5 %**

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

This is an 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 (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 3 %

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 1000yrs) would send the system back to class A. A mixed fire (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	50	50	500	0.02	10
Mixed	175	15	250	0.00571	3
Surface	6	1	20	0.16667	87
All Fires	5			0.19238	

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)

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LANDFIRE Biophysical Setting Model

***Biophysical Setting* 3914120** **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**

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Modeler 3			**Reviewer**	Jim Drake	jim_drake@natureserve.org

Vegetation Type

Upland Grassland/Herbaceous

Map Zone

39

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 ANGE
SONU2
BOCU
HESP11

General Model Sources

☑ Literature
☐ Local Data
☑ Expert Estimate

Geographic Range

This BpS would have occurred in ECOMAP Sections/Subsections 222L (all-highest concentration would have been in this Section), 222K(all), 222R(all), 251Ba and 222M (all). 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.

In MZs 39 and 40, this would be in the eastern portion. It would occur in ECOMAP sections 222M, 222N, 251A and 251B.

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 this type in WI. 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

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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 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). 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 et al. (1999).

Vegetation Description

Grasses formed the matrix of this prairie system 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 1.0-1.5m 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 a mix of 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 of 0-10% closure for prairie, 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. 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.

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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.

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 western WI and MN, and the eastern Dakotas, there was a grazing and fire interaction. This was probably minimal in the 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.

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

Health and vigor of the sod influences shrub or 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 or even Northern Tallgrass Prairie in the eastern Great Plains.

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

There are also invasive woody species such as buckthorn, Russian olive, and salt cedar. These species pose significant threats in tallgrass prairie.

Today this system has severely reduced native cover (approx. 99% loss) due to conversion to other uses such as agriculture. Alteration of the type is due to grazing and reduced fire resulting in greater shrub and tree component (eastern redcedar (Juniperus virginiana) and 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.

Currently, there would be much less of class A than historically.

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.

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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).

Conversion of prairies to cropland and pastures has eliminated much of this system in MZs 39 and 40.

Native Uncharacteristic Conditions

Many small trees and shrubs would be uncharacteristic of this system historically but occurs today where there are nearby seed sources due to the lack of fire. Domestic livestock grazing has eliminated many native species and has altered species composition. Conversion of prairies to cropland and pastures has eliminated much of this system in MZs 39 and 40.

Scale Description

Within regions of varied topography, type patches are typically small (<200ac) limited by topography, but in regions of level topography on extensive sands and gravel deposits these could be much larger.

This would be a small or medium patch community on the floodplains or sandplains if in the Great Plains.

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).

This system is at the western edge of its distribution in the northern Great Plains (MZs 39 and 40). Its species distribution in these grassland-dominated mapzones will be somewhat different than in further east. Many areas in these mapzones have been converted to pasture and planted with exotic grasses. These conversions make it difficult to determine the historical vegetation because they are so thorough.

Comments

This model for MZs 39 and 40 was adapted from the draft model from the same BpS from MZs 41, 50 and 51 created by John Harrington jaharrin@wisc.edu and Richard Henderson richard.henderson@wisconsin.gov. Model for MZs 41, 50 and 51 was reviewed at the Vegetation Modeling Workshop by Elena Conteras, Randy Swaty, Mike Kost, Chris Weber, Doug Cox and Becky Schillo.

This model for MZs 41, 50 and 51 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 and 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 (RA) 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.

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Vegetation Classes

Class A 80 %

Early Development 1 Open

Upper Layer Lifeform

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

Fuel Model 3

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.

Description

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 (Echinacea 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 tallgrass prairie forbs and shrubs with little or no tree regeneration.

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
- [x] 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 3.0m
Tree Size Class	Seedling <4.5ft	

- [x] 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. Quaking aspen and oaks are also present in the upper canopy, especially in northwest MN. In some areas, particularly northwestern MN, aspen (Populus tremuloides) could invade along with or instead of oaks. This vegetation is experiencing recurring fires in advanced oak regeneration, which stimulates the resprouting grubs. Fuel

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complexes are characterized as "stunted brush prairie" comprised of mixed prairie grasses and forbs with shrubs and coppicing oak and/or aspen stems about 1.0-1.5m 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 were to go 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 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 class 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. So - all of these variabilities, we're modeling fire as having the ability to take back to A with 0.04 probability.

It is questionable as to whether this stage is truly part of this system or whether it's transitioned to another type.

Class 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 class C.

Class C **5 %**

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 increase 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

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This is a savanna type class - a "grown up" oak shrubland. Aspen is another indicator in the upper canopy, especially in northwest MN. 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 class 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. Class C 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 you get over 20%, this goes into another 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 class A, but would be very unlikely. Replacement fires, modeled at the probability of occurring every 25yrs, could also take this class 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 (class 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

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:** II

Historical Fire Size (acres)

Avg 200
Min 1
Max 2000

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	4	1	8	0.25	96
Mixed					
Surface	90			0.01111	4
All Fires	4			0.26112	

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
- [ ] Other (optional 1)
- [ ] Other (optional 2)

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PERSONAL COMMUNICATION:
Oak-Hickory FRCC modeling group

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LANDFIRE Biophysical Setting Model

Biophysical Setting 3914200 Northern Tallgrass Prairie

☑ *This BPS is lumped with: 1421, 1488*

☐ *This BPS is split into multiple models: Don't map 1421, include it in here. Also don't map 1488. In easternmost SD and MN, lump it into 1421/1420, as was done for the Great Lakes mapzones.*

General Information

Contributors (also see the Comments field **Date** 4/24/2007

Modeler 1	Tom Bragg	tbragg@mail.unomaha.edu	**Reviewer**	Tom Bragg	tbragg@mail.unomaha.edu
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Vegetation Type

Upland Grassland/Herbaceous

Map Zone

39

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 SPHE
PAVI2 HESP11

ELTRS

General Model Sources

☑ Literature
☐ Local Data
☑ Expert Estimate

Geographic Range

This would occur in TNC's ecoregion Northern Tallgrass Prairie or ECOMAP subsections 222Na and 251Aa down south through 251Bf. This occurs in the eastern portion of MZs 39 and 40.

This type encompasses Bailey's Ecoregion 251. See Samson et al. 1998.

This system is found primarily in the Northern Tallgrass ecoregion ranging along the Red River basin in MN and the Dakotas to Lake Manitoba in Canada. It constitutes the northernmost extension of the "true" prairies (NatureServe 2007).

Biophysical Site Description

Soils are typically deep mollisols. Surface soil textures are primarily loam, silt loam and silty clay loam and the landscape is level to gently rolling. Glacial activity shaped the landscape of this type and landforms of the region reflect this. They are primarily glacial lakeplains, alluvial outwash fans, beach ridges. Potholes (shallow depressional wetlands) are also embedded within the tallgrass prairie landscape. These wetlands range in size from tenths to hundreds of acres.

Precipitation ranges from 17-36in.

Vegetation Description

Grassland groupings of the Northern Tallgrass Prairie are the bluestem prairie from southern Manitoba

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through eastern ND and western MN, and the wheatgrass, bluestem and needlegrass area from south-central Canada through east-central ND and SD (Samson et al. 1998). The northern character of this type is reflected in the greater proportion of cool-season than warm-season species that characterize the southern tallgrass prairie. Andropogon gerardii generally is the principal dominant in the uplands with lesser abundance of Sorghastrum nutans compared to tallgrass prairies further south (Carpenter 1940, Smeins and Olsen 1967) and the generally higher abundance of species such as Elymus trachycaulus ssp. subsecundus, Elymus canadensis, Koeleria macrantha, Stipa spartea and Sporobolus heterolepis. The grasses are characteristically tall (~1-2m) and vegetative cover is high. Wetter areas and lowlands are dominated by species such as Spartina pectinata with Carex spp abundant in the understory. Historically, woody vegetation was limited to fire-protected areas (e.g. along larger riparian areas). In the west, cool season and mid-height grasses were more characteristic of the dominants (i.e. Pascopyrum smithii).

Disturbance Description

Fire and grazing were the dominant disturbances in this type.

Fire: Fire return interval was short with stand replacement fires occurring approximately every 3-5yrs (Wright and Bailey 1982). As grassland fires go, these are high severity fires with high fuel loads during dormant season headfires. It was even possible to have more than one fire in a growing season with the high fuel loading that occurred in this region (Severson and Sieg 2006). Because rate of spread is high and residence time low, though, the effect of fire on below-ground biota was of little if any consequence. The above-ground component is consumed during burning but the plants themselves remain (below ground) and return in approximately the same composition as occurred before the fire. With few exceptions (e.g. space for annuals – Linum rigidum, etc. – to germinate), before-fire composition is the same as after-fire composition with the plants generally growing more vigorously.

Fuel accumulation occurs more slowly in the more xeric mixedgrass prairie than in the more mesic tallgrass prairie (Bragg 1995) which results in a more frequent MFRI for tallgrass prairie. Also, precipitation in the tallgrass prairie area is greater than in prairies to the west thus woody plant invasion is not as rapid, although it occurs in both ecosystems. Differences in plant production, MFRI, historic grazing conditions (the mixedgrass prairie is the center of the bison range) and species composition (and interactions among all of these) suggests that tallgrass prairie functions differently than mixedgrass.

Grazing: Bison, with peripheral help from grasshoppers, elk, antelope and a myriad of smaller animals made herbivory one of the dominating factors of the northern tallgrass prairie (Severson and Sieg 2006). With estimates of 30-60 million bison in the Northern Great Plains (Isenberg 2000), herbivory by large mammals also was a significant disturbance to the grasslands. Bison herbivory occurred in a mob grazing or flash grazing method, with extensive herds migrating across the prairie as they graze. Modern rotational grazing systems simulate this by resting areas after intensive grazing. Elk, too, may have played an important role than generally believed, particularly in the eastern portion of the zone. Whether bison or elk, large mammals preferentially grazed recently burned sites.

Disturbance from the interaction of fire and grazing, when combined with climatic gradients and landscape features (geography, hydrology and topography), created a mosaic of vegetative structure across the Northern Tallgrass Prairie landscape. Without these disturbances, Northern Tallgrass Prairie most likely would have succeeded to shrubland or woodland. Changes in the location of the prairie-forest ecotone may have occurred over the millennia. In the absence of human intervention (e.g. prescribed fire, aggressive woody plant removal, etc.) much of the Northern Tallgrass Prairie could succeed to shrubland or woodland.

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Fire and grazing disturbances would have similar effects in temporary and seasonal wetlands, as well as in the wet meadow zone of the semi-permanent wetlands. Ponded wetlands would add to the patchy/mosaic nature of the fire effects over the landscape. Pothole hydrology is highly influenced by annual and long term climatic gradients - wet and drought cycles have persisted through history.

The climate would have also played a pivotal role in the development of the grasslands, especially considering that periodic droughts would have limited growth and expansion of trees. It is important to consider the climatic extremes in portions such as the tallgrass prairie of the Dakota's and western MN to understand the distribution of grasslands, not the long-term averages. As an example, the drought of the 1930's would have significantly impacted the vegetation on the landscape, especially reducing woody vegetation. Also, during drought years, other factors such as grazing and fire would have even had a stronger impact on the vegetation."

Adjacency or Identification Concerns

Depending on historic drought conditions, the ecotone between 1420 (and adjacent savannas) and 1132 may have shifted latitudinally. Northern Tallgrass Prairie is similar to the Central Tallgrass Prairie which abuts and grades into the Northern Mixed Prairie to the west, and into Oak Savanna to the east, and aspen parklands to the north and east.

This system is similar to Western Tallgrass BpS 1150. Models are very similar.

Within Northern tallgrass prairie, saline areas with high water tables exist and have formed unique vegetative communities.

The vast majority of the Northern Tallgrass Prairie has been converted to agricultural production or urbanization, leaving less than one percent of the native sod (Samson and Knopf 1998).

An estimated 98% of historic wetlands of this zone have been lost. Remaining wetlands are often highly degraded (i.e., sediment-filled, invaded by non-native plants, poor water quality due to agricultural runoff).

There was also some debate in MZs 39 and 40 as to whether or not potholes should be lumped into the tallgrass systems. It was decided that they would be split out. When there is water, the potholes are a system. Drought converts the aquatic system to terrestrial. The system goes in and out of existence based on weather patterns. There is also a temporal shift where potholes might go out of existence. Permanent wetlands are further east, but further northwest through to western Dakota, they go in and out of this pothole state.

Cattle grazing practices (equal use across pastures) have resulted in more continuous plant matter (= fuel) causing more uniform fires across the landscape where, with bison grazing, fires may have been more patchy. Heavier grazing also may have altered the species composition, perhaps favoring more cool-season species over warm-season species which would affect both MFRI and the season during which fires might occur. Differences in bison and cattle grazing may have affected the invasibility of prairie by woody plants which, ultimately, would affect fire conditions.

Unmanaged prairie remnants are heavily invaded with woody vegetation and invasive species such as smooth brome, Kentucky bluegrass, and noxious weeds such as Canada thistle, leafy spurge, plumeless thistle, bull thistle, etc. Wetlands are often dominated by monotypic stands of non-native reed canary grass

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varieties or narrow-leaf and/or hybrid cattail.

There are also invasive woody species such as buckthorn, Russian olive and salt cedar. These species pose significant threats in tallgrass prairie.

Grassland areas that are heavily invaded with smooth brome or Kentucky bluegrass may appear similar to native sod areas simply because of grass presence, regardless of species composition or structure.

Very little of classes A and B remain on the landscape today; most is in classes C or D.

Native Uncharacteristic Conditions

Some riparian areas may contain woody cover that would have been protected from fire and experienced minimum grazing intensity.

Cattle grazing practices (equal use across pastures) have resulted in more continuous plant matter.

Scale Description

Disturbance varied widely in size. Fires would have ranged from local (tens of acres) to landscape level (thousands of acres). 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.) or a weather event (precipitation, wind direction change, humidity change, etc.). Growing season (mid May to mid Aug) 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. Mosaic fires were probably a result of patchy disturbed areas, topography, geography, hydrology and climate.

Bison herbivory occurred in a mob grazing or flash grazing method, with extensive herds migrating across the prairie as they graze. Modern rotational grazing systems simulate this by resting areas after intensive grazing.

Issues/Problems

Adjusted native grazing in class A in BpS 14200 from 0.6 to 0.3 to get reference conditions to improve in LANDSUM (M.H. Weber 1/17/08 at MFSL). There was some debate in MZs 39 and 40 as to whether or not potholes should be lumped into the tallgrass systems. It was decided that they would be split out. When there is water, the potholes are a system. Drought converts the aquatic system to terrestrial. The system goes in and out of existence based on weather patterns. There is also a temporal shift where potholes might go out of existence. Permanent wetlands are further east, but further northwest through to western ND, they go in and out of this pothole state.

Modelers for MZs 39 and 40 used best professional judgment to estimate the historic tallgrass prairie conditions. This area is highly converted to cropland and good examples of historic vegetation communities are rare. We did not change many of the model dominant species or class indicator species. These do vary across the NTGP - there may be literature or experts who could help refine these for the whole system. We did not feel comfortable with some of the species listed but much of our knowledge is based on the present conditions and our experience with our local work areas.

Comments

This model for MZs 39 and 40 was adapted from the Rapid Assessment model: R4PRTGn Northern

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Tallgrass Prairie created by Jim Drake jim_drake@natureserve.org and Jim Decoster jim_decoster@nps.gov and reviewed by Daryl Smith daryl.smith@uni.edu. Other modelers for MZs 39 and 40 were Sandy Smart (Alexander.Smart@sdstate.edu) and Shane Del Grosso (shane_delgrasso@fws.gov) and Sara Vacek sara_vacek@fws.gov. Reviewer for MZs 39 and 40, Tom Bragg, however, suggested some changes, based on co-RL recommendations. Therefore, Tom Bragg's name was added to the modeler names, and original modelers were told of this change. Original modeler names still retained, as most of the model stayed the same.

Vegetation Classes

Class A 49 %

Early Development 1 All Structure

Upper Layer Lifeform

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

Fuel Model 1

Indicator Species* and Canopy Position

ANGE	Upper
PAVI2	Upper
HESP11	Upper
SONU2	Upper

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	40 %
Height	Herb 0m	Herb >1.1m
Tree Size Class		

- [ ] Upper layer lifeform differs from dominant lifeform.

Description

This is the post-fire, post-grazing community from immediately after a replacement fire until one year after the fire. Immediately following the fire, there are no above ground plants and no litter. Plants emerge within weeks and typically, within a year, the grasses range from 1- 1.75m high. For a spring burn, ideally this stage would only last three months; therefore, this stage was modeled to end at one year. This also represents the post-grazing stage with grasses and forbs grazed and kept to a low stature. Graminoids are abundant but the forb component is higher in this stage than others. Dominant species are those common to the Northern Tallgrass Prairie - Andropogon gerardii, Panicum virgatum, Koeleria macrantha and Stipa spartea; they are present but much shorter and in somewhat less abundance. Some forbs are more abundant in the immediate post-fire vegetation. There were a wide diversity of early successional forbs, such as Artemisia ludoviciana and Ambrosia artemisifolia. Carex spp. Are also present in the lower layer.

Annual burns and sometimes two burns in a single year (spring burns can easily be followed by fall, dormant season burns) can occur in some spots. For fire (and to some extent grazing) in pre-European times, there really are only two basic stagesL (1) immediately after the fire (until fuel accumulates) and (2) before the next fire (which is any time after a year's growth has accumulated as fuel – a fire can occur as soon as this amount of fuel is available). You can make further subdivisions if you want, such as the time until fuel accumulates to pre-burn conditions but this is difficult to identify (not easily mapped) and isn't really an important factor in burning since a fire can occur with only one growing season's fuel accumulation. It seems that historically, any portion of the mapzone that did not burn would have succeeded to trees some time ago and that, at least theoretically, there would be little if any of this sere in the pre-European landscape. Subsequent stages occur today in the absence of historic disturbances.

Most likely fires occurred at least every 5-7yrs in the Northern TGP (3-4yrs in the central TGP). Further, fires in class A would not have substantially changed the community composition. In this ecosystem a "replacement" fire only removes litter and some standing plant matter, it does not change composition (except for uncommon annuals).

Because of LANDFIRE mapping rules, canopy cover is arbitrary number. These classes should actually be defined on the ground by biomass, litter and species.

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Very little of A or B remain on the landscape today; most is C or D.

Grazing was modeled to occur on 60% of this class each year - modified to 30% at MFSL by M.H. Weber to get model to represent reference proportions correctly in LANDSUM..

Class B **44 %**

Mid Development 1 Closed

Upper Layer Lifeform

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

Fuel Model 3

Indicator Species* and Canopy Position

ANGE	Upper
PAVI2	Upper
SONU2	Upper
HESP11	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	41 %	100 %
Height	Herb 0m	Herb >1.1m
Tree Size Class		

☐ Upper layer lifeform differs from dominant lifeform.

Description

This is the community that develops post-fire after a few months or a year or so.

The immediate post-fire community differs briefly (three months or so) from pre-burn conditions except for litter. One growing season after a burn (that's one year or less), it would be difficult to map the burned area.

Class B is the successional state from class A in absence of fire, grazing, or other disturbance for a year. The structure is more closed and taller, there is some thatch buildup but this is still limited due to the limited time since fire. Tall grasses are still dominant, woody vegetation (shrubs and trees) are widely scattered and limited to micro sites that escaped fire or to mature fire resistant trees. Both of these occur more commonly in the eastern parts of this Type. Dominant species are still those common to the Northern Tallgrass Prairie - Andropogon gerardii, Panicum virgatum, Sorghastrum nutans and Stipa spartea. Carex spp. are also present in the lower layer. This paragraph (above) describes little difference between shortly after a fire and some year or so after a fire.

Because of Landfire mapping rules, canopy cover is arbitrary number. These classes should actually be defined on the ground by biomass, litter, species.

This class can also be distinguished from A based on fuel model (fuel model 3 for class B vs fuel model 1 for class A) and biomass.

Fire was modeled to occur every five years altogether, causing a transition to A half the time and half the time remaining in B. In dormant season burns, everything above ground is burned. Historically, however, grazing would have resulted in patchy fuel which would have resulted in patchy burns such that only a percentage of the total area would have burned.

Grazing was modeled to occur on 30% of this class each year, half the time causing a transition back to A and half the time remaining in this class.

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Class C 5 %

Late Development 1 Closed

Indicator Species* and Canopy Position

HESP11	Middle
ANGE	Upper
PAVI2	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	20 %
Height	Shrub 0m	Shrub 3.0m
Tree Size Class		

Upper Layer Lifeform

- ☐ Herbaceous
- ☑ Shrub
- ☐ Tree

Fuel Model 1

☑ Upper layer lifeform differs from dominant lifeform.

Grasses are dominant, at least 75%.

Description

This class reflects fuel accumulation beyond that normal for tallgrass prairie. Historically (at least theoretically), this would not have been a significant component of the ecosystem since, what we know today, once woody plants are established, there is little that will get rid of them. This would have resulted in permanent, established woody areas in protected areas but with less of the landscape transitioning to this class. Woody plants were not historically reported to be expanding their range. Sites in this class are beyond the normal fire return interval. Litter buildup is high and fires in this class would likely be intense. Woody vegetation is still limited but increases with time since fire. This class will have more of a woody component than other classes except class E, but the woody component is mostly shrubs (e.g., Prunus, Sumac, Cornus, etc). Dominant species are those common to the Northern Tallgrass Prairie - Andropogon gerardii, Koeleria macrantha, Panicum virgatum and Stipa spartea.

This class starts at eight years and ends at 11yrs.

Replacement fire was modeled to occur approximately every five years due to fuel accumulation. It causes a transition back to A. Grazing was also modeled to occur on 15% of this class each year, causing a transition back to A.

Class D 2 %

Late Development 1 All Structures

Indicator Species* and Canopy Position

POTR5	Upper
QUMA2	Upper
ANGE	Middle
RHGL	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	20 %
Height	Tree 0m	Tree 10m
Tree Size Class		

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 3

☑ Upper layer lifeform differs from dominant lifeform.

The dominant lifeform is still a grassland component, however, woody vegetation has encroached to the point of (primary shrub, some trees) reaching a state where they can no longer be removed by fire. Grasses comprise 60% and shrubs/trees 40%.

Description

Class D reflects both fuel accumulation and establishment of woody plants.

Shrub/scrub where woody species have been able to become savanna live because off disturbance (fire and/or intense grazing). Quaking aspen (Populus tremuloides), bur oak (Quercus macrocarpa), willow (Salix spp.), hazel (Corylus spp.) and alder (Alnus spp.) are the most common and can form dense thickets, although the bur oak and quaking aspen are small in size and make up 2-5% of the class; dogwood might also be present.

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Grasses are still abundant in the understory and include Andropogon gerardii, Panicum virgatum, Koeleria macrantha and Stipa spartea.

Replacement fire is modeled to occur every 5-10yrs causing a transition back to A. However, present data suggest that, at least with deciduous species, fire does not remove the woody plants thus a fire of any type in this category might have kept it in D but just reduced the size of the woody plants. However, it is also thought that historically, this class would not have occurred frequently and therefore, fire would still be going through the landscape on a frequent basis. Grazing was also modeled in this same way.

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 3500
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	6			0.16667	100
Mixed					
Surface					
All Fires	6			0.16669	

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)

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LANDFIRE Biophysical Setting Model

Biophysical Setting 3914690 Eastern Great Plains Floodplain Systems

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

General Information

Contributors (also see the Comments field **Date** 7/15/2007

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Modeler 3			**Reviewer**		

Vegetation Type
Wetlands/Riparian

Map Zone
39

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 SANI
PODE3 CORNU
SAAM2 ULAM
FRPE

General Model Sources
☐ Literature
☐ Local Data
☑ Expert Estimate

Geographic Range

This occurs in the southeast corner of MZ39. This is akin to Midwestern Floodplain - around ECOMAP subsections 251Bf and 251Ba and southeast.

This system is found along rivers across the glaciated Midwest. This system is found along medium and large river floodplains throughout the glaciated Midwest ranging from eastern KS and western MO to western Ohio and north along the Red River basin in MN.

It's difficult to determine geographically where the western model ends and the eastern model starts, but probably around Yankton, SD or perhaps up to Fort Randall Dam might be a good dividing line for eastern versus western on the Missouri River.

Biophysical Site Description

It occurs from river's edge across the floodplain or to where it meets a wet meadow system. It can have a variety of soil types found within the floodplain from very well-drained sandy substrates to very dense clays.

This ecological system occurs in floodplains of medium to large rivers. It primarily is found on alluvial soils ranging from sandy to very dense clays.

Vegetation Description

It is this variety of substrates and flooding that creates the mix of vegetation that includes Acer

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saccharinum, Populus deltoides, willows, especially Salix amygdaloides and Salix nigra in the wettest areas, and Fraxinus pennsylvanica, Ulmus americana and Quercus macrocarpa in more well-drained areas. Within this system are oxbows that may support Nelumbo lutea, Numphaea odorata and Typha latifolia. Understory species are mixed, but include shrubs, such as Cornus drummondii and Asimina triloba (in KS), sedges and grasses, which sometimes help form savanna vegetation.

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 and S. amygdaloides, occurring more in the western range of this system. Fraxinus pennsylvanica, Ulmus americana and Quercus macrocarpa occur in more well-drained areas. 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.

Associations:
•Acer saccharinum - Celtis laevigata - Carya illinoinensis Forest (CEGL002431, G3G4)
•Acer saccharinum - Ulmus americana Forest (CEGL002586, G4?)
•Acer saccharum - Carya cordiformis / Asimina triloba Floodplain Forest (CEGL005035, G2)
•Betula nigra - Platanus occidentalis Forest (CEGL002086, G5)
•Brasenia schreberi Herbaceous Vegetation (CEGL004527, G4?)
•Calamagrostis canadensis - Juncus spp. - Carex spp. Sandhills Herbaceous Vegetation (CEGL002028, G3G4)
•Calamagrostis stricta - Carex sartwellii - Carex praegracilis - Plantago eriopoda Saline Herbaceous Vegetation (CEGL002255, G2G3)
•Carex pellita - Carex spp. - Schoenoplectus tabernaemontani Fen Herbaceous Vegetation (CEGL002041, G1)

Alliances:
•Acer saccharinum Temporarily Flooded Forest Alliance (A.279)
•Acer saccharum - Carya cordiformis Temporarily Flooded Forest Alliance (A.302)
•Andropogon gerardii - (Sorghastrum nutans) Temporarily Flooded Herbaceous Alliance (A.1337)
•Betula nigra - (Platanus occidentalis) Temporarily Flooded Forest Alliance (A.280)
•Brasenia schreberi Permanently Flooded Herbaceous Alliance (A.1742)
•Carex (rostrata, utriculata) Seasonally Flooded Herbaceous Alliance (A.1403)

Disturbance Description

Flooding is the primary dynamic process, but drought, grazing and fire have all had historical influence on this system.

This system is primarily controlled by moderate to frequent flooding. Grazing can also impact this system and can lead to decreased cover of many graminoid species in some areas. Grazing was not modeled due to lack of data.

Beaver influence was modeled.

Adjacency or Identification Concerns

Federal reservoirs have had a serious and negative effect on this system, along with agriculture that has converted much of this system to drained agricultural land.

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This system is distinguished from floodplain systems northeastward, Laurentian-Acadian Floodplain Forest (CES201.587), and eastward, Central Appalachian Floodplain (CES202.608). Celtis and Populus deltoides are absent (or essentially so) from the Laurentian-Acadian type.

This system is easily identified by using flood plain which is covered by a 10yr event. Surrounding vegetation could vary from forested to grass prairie transition or bare rock or rock outcrops for instance in the Badlands, White River in SD, and on the Cheyenne. It is adjacent to grassland with some woody draws in the river breaks.

This system might be very difficult to distinguish from 1162 Western Great Plains Floodplain Systems. There is actually only a Midwestern Floodplain and a Great Plains Floodplain, not an Eastern and Western Great Plains Floodplain. This 1162 Western Great Plains Floodplain is akin to Great Plains Floodplain, whereas 1469 Eastern Great Plains Floodplain is akin to Midwestern Floodplain. It's difficult to determine geographically where the Western model ends and the Eastern model starts, but probably around Yankton, SD or perhaps up to Fort Randall Dam might be a good dividing line for eastern versus western on the Missouri.

Russian olive and tamarisk may be invaders. Tamarisk comes in with cottonwood and willow in earliest post-disturbance stage, although tamarisk is an invader more in the Great Plains region. Russian olive might affect later successional stages - after 10yrs, usually at approximately the time that green ash comes in.

Eastern red cedar is invasive in the floodplain forest along the Missouri River at Yankton and below, and on reaches farther upstream. Indications are that eastern red cedar would have been less prevalent historically than today due to fires and less grazing pressure. Eastern redcedar has increased on floodplains especially due to fire suppression. Also - flood control and channel degradation have been a dominant influence favoring historic redcedar increases on the Missouri River floodplain, at least below Yankton. Many of redcedar trees on river below Yankton appear to be 30-40yrs old, tying in well with the period that the dams have been in place. Frequent flooding likely kept redcedar scarce on lower floodplain surfaces in the pre-dam era. How far north and west eastern redcedar would have occurred along our rivers originally is questionable (Gary Larson, pers comm).

Leafy spruce, Smooth brome and Canada thistle, might invade also, especially along lower reaches. Russian knapweed might also invade.

The natural flooding frequencies have been changed by the modern water control structures (dam and irrigation projects). Flooding intensity has been altered by construction of small impoundments on tributaries as well as larger impoundments on the main-stem rivers. Decreased flood frequency along the Little Missouri River decreased cottonwood abundance.

Agricultural activities have change seral development and introduced invasive plant species to the BpS.

Woodcutters along the system operated from the earliest days (1860s) to supply wood to the paddlewheelers plying the river. They cut many of the early stands along the river.

There are thousands of smaller dams on watersheds in addition to the large control structures that are altering hydrology today.

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American elms are less dominant today than historically, and they are smaller than historically, due to Dutch Elm disease, but they are still numerically abundant.

Livestock grazing is now different versus historically. The effects of cattle versus bison grazing on the floodplains is very different.

Currently, unpalatable sagebrush cover might be higher today (although not as much in the midwest), but chokecherry and associates might be getting wiped out. Bison would have grazed on top and wouldn't have hung out in the floodplain, whereas cattle are there regularly. Cows graze all tree and shrub seedlings, and the seedling re-establishment is episodic, and now re-establishment is stretched out further due to the livestock. They are removing much of the woody vegetation, and they are also hammering the grassland more intensely (Dave Ode, pers comm.).

Johnson (1992), in a study of Missouri River floodplain forests in central ND, determined that the pre-settlement forest was, in fact, dominated by early successional stages. He reports that young pioneer stands (<40yrs old) comprised 47% of the forest, while older pioneer stands (40-80yrs old) comprised 25% of the forest; that transitional forest (80-150yrs old) comprised 21% of the forested acreage and that equilibrium stands (dominated by green ash,elm, oak, etc.) (>150yrs old) comprised only seven percent of the forested acreage. Johnson (1992) also demonstrated that with construction of Garrison Dam and subsequent cessation of flooding, there is a continuing shift to older forest stages and very little recruitment of new, early successional forest; the very types that once dominated the Missouri River floodplain and provided habitat for its varied native wildlife (Ode 2004).

Over the past 37yrs much has changed in the cottonwood forest of LaFramboise Island in SD. As the density of cottonwoods has declined (at a rate of about two per acre per year), the number of junipers and, to some extent, green ash have dramatically increased. In cottonwood forests throughout much of the upper Missouri River Valley, green ash is one of the most important tree species to colonize cottonwood forests and, over time, becomes the dominant forest tree (Ode 2004). Whatever the dominance of green ash in the future forest, it will likely be overwhelmed if not over-shadowed by the massive number of junipers which are now developing in the LaFramboise Island forest understory (Ode 2004). Cottonwood is declining.

Junipers are notoriously vulnerable to fire. On the presettlement landscape of the northern plains, where prairie fires were frequent events, juniper woodlands were restricted to fire-protected environments like river breaks, badland escarpments, buttes and islands (Ode 2004).

There might be some difficulty distinguishing the Floodplain Systems from the Riparian from the Wooded Draw/Ravines - and where to assign smaller, second and third order prairie streams. The second and third order prairie streams can sometimes have cottonwood and be like small rivers (Riparian, Floodplain); sometimes they are dominated by other woodies such as water birch, boxelder, green ash (Wooded Draw/Ravine) and willows, depending on how far east you go; sometimes they have very few woody plants other than silver sagebrush. Streams in the eastern half of MT (east of the Big Snowies) could probably be modeled as either a cottonwood successional sequence or a woody draw successional sequence, depending on the size of the drainage basin. If the basin is big enough there will eventually be a flood big enough to result in cottonwood regeneration. This is especially true now that we have all the impoundments in the headwaters of these prairie streams. Drainages that just don't have the area to get a good flood would probably have been some sort of woody draw, dominated by green ash in the eastern third of the state or other woodies like hawthorn or chokecherry in the more western part of the Great Plains. In terms of

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assigning the drainage to one or the other type of system would depend on basin size.

Rivers and streams that have had impoundments (current conditions) for 50yrs or more probably have more class D than presettlement but less class A and B. Class A and B currently has tamarisk. Class C and D have Russian olive currently. Several exotics, such as Canada thistle, Kentucky bluegrass and quackgrass are ubiquitous in classes B through E currently.

Native Uncharacteristic Conditions

Scale Description

This BpS occurred in a linear dimension, with smaller areas covered in tributary rivers and streams. Wetland complexes include oxbow lakes, slough and marshes.

Issues/Problems

Comments

This BpS for MZs 39 and 40 was created from the NatureServe description as well as adaptations from BpS 1162 from MZs 39 and 40 created by Dave Ode, modeled by Elena Contreras and reviewed by Gary Larson, Mark Dixon and John Ortmann. Changes were made to better fit the eastern vegetative and functional components. Model for 1469 similar to 1162, except that class E is removed for 1469, as it is not present for the east. Evolution of 1162 can be found in BpS 1162 Comments description.

Vegetation Classes

Class A **15 %**

Early Development 1 All Structure

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

PODE3	Upper
SAAM2	Upper
SALU2	Upper
SCHOE6	Low-Mid

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	50 %
Height	Tree 0m	Tree 5m
Tree Size Class	Sapling >4.5ft; <5"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Description

The upper layer lifeform is comprised of a seedling and sapling shrub (willows) and tree component. Trees might be more abundant/frequent. Shrubs of any cover and 0-1m are in this class.

This class is created by deposition, stream meander changes, point bar formation and scouring.

This class lasts for approximately 15yrs.

The upper layer lifeform is comprised of a seedling and sapling shrub (willows) and tree component and dominated by a young canopy of tree saplings and shrubs after a few years. Trees might be more abundant/frequent.

Sandbar willow, Salix interior is invariably the first which makes its appearance on the newly made lands on the borders of the Mississippi and Missouri, and seems to contribute much towards facilitating the operation of raising this ground still higher; they grow remarkably close and in some instances so much so that they form a thicket almost impenetrable (from Meriwether Lewis during the Lewis and Clark expedition in 1804

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to 1806, from Ode 2004).

Pioneer tree and shrub species of cottonwoods and willows. The understory is highly variable and consists of bare sand, annuals, or perennial hydrophytes. Species would include various grass, sedges and rushes. Annuals become less and less common after 10yrs as the rhizomatous perennials take hold. Herbaceous understory of sedges (bulrushes) and native annuals in wet areas. In the early few years of this stage, most of the area is bare sand. Age 0-4yrs for the first part of this class, then 5-14yrs for the second part of this class. Acer saccharinum and Salix nigra are also indicators.

Most of area is seasonally flooded. Much bare, wet-alluvium habitat for cottonwood establishment is created each year during spring floods. However, most all of these will be swept away by the next year's flood in the early part of this class. It is probably only every 10-20yrs that flooding occurs up high enough on point bars and low terraces to establish cottonwoods and then allow them to escape flooding until they are large enough to persist - in the early part of this class.

During the second part of this class, at age 5-14yrs, minor flooding occurs every 20yrs, advancing this stage to the next; deposition causes the terrace to build and become higher and drier. This was modeled as alternate succession. Lack of flooding actually maintains the stage.

Major flooding occurs every 50yrs, bringing it back to the beginning of this stage. This was modeled as wind/weather stress.

Beaver disturbance occurs in this class. The closer to the river, the more likely it is. It was modeled as "optional 1". Beavers, however, do not have as much of an impact in stands less than 10yrs old unless there is nothing else in the area. Beaver activity is quite variable. It was modeled as occurring on one of this class on the landscape each year, maintaining this class.

After 15yrs, this class succeeds to the mid-development closed stage.

Johnson (1992) states that young pioneer stands (<40yrs old) comprised 47% of the forest historically.

Class B **30 %**

Mid Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

PODE3	Upper
SAAM2	Mid-Upper
SALU2	Middle
FRPE	Low-Mid

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.

Description

This stage develops as the stand starts to mature. This community tends to be partially opened, with scattered cottonwoods and willows. Stands of cottonwoods 20-50yrs old can be fairly dense, although there are usually some openings. The shrub layer is highly variable and may include species such as rose, snowberry, chokecherry and dogwood.

Green ash begins to establish in cottonwood stands when they are approximately 20yrs old (Lesica and Miles 1999). Silver maple can also be an indicator.

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The understory vegetation is highly variable. Age is 15-50yrs, succeeding to class C, a late closed stage.

Willows slow current and create deposition on top. The vegetation helps anchor and causes deposition which decreases flood frequency. Flooding leading to deposition occurs every 50yrs, promoting succession to the next stage by raising the level of the terrace (modeled as alternate succession). Major flooding also occurs approximately every 50yrs, bringing this class back to the early class A stage (modeled as wind/weather stress).

Replacement fires were modeled as occurring every 150yrs. It would probably only burn in drought, as fires would be very rare. It has been suggested that stand replacing fires might not occur in this class because it might be too wet for fire. However, due to lack of data, replacement fires were kept in the model. It is questionable whether replacement fire would set this stage back to the beginning of class A, as the terrace would be too high and dry to provide conditions for successful establishment of cottonwood and willow from seed. If the cottonwoods resprouted, it would be more like the middle of class A because the understory would be more mature than the beginning of class A; if the cottonwoods didn't resprout, it would probably just be a willow stand. Replacement fire was however modeled as taking this class to class A.

Low severity and mixed fire also occur every 100yrs, combined, and would not cause transition to another stage.

Beaver disturbance occurs in this class. The closer to the river, the more likely it is. It was modeled as "optional 1". Beaver activity is quite variable. It was modeled as occurring on one of this class on the landscape each year, thus maintaining this class.

It has been suggested that Native Americans likely burned (low severity fires) these areas more often than every 100yrs. However, another reviewer questioned that and stated that they probably didn't burn these areas but rather the surrounding area, since this area would be too difficult to burn due to too much shade and humidity. Also, some sites were likely heavily grazed by bison (low severity fire sites) and horses near camps. However, the model was retained as is, as no confirming feedback was received.

Class C **40 %**

Late Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Indicator Species* and Canopy Position

PODE3	Upper
ACSA2	Mid-Upper
FRPE	Low-Mid
ULAM	Middle

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	61 %	80 %
Height	Tree 25.1m	Tree 50m
Tree Size Class	Very Large >33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

Tree height maximum probably only goes to approximately 30-35m. Western portions will be shorter.

Description

This class is a mature, late seral closed canopy cottonwood floodplain forest. Overstory is dominated by cottonwood and green ash. Box elder is a frequent component of this class for MZs 39 and 40 but is not as common as green ash. (Some modelers/reviewers thought that the system is becoming drier in this class allowing western wheatgrass to come in; however, others questioned that.)

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At least four studies along the Missouri River in southeastern SD have described aspects of a successional sequence that begins with colonization by cattails or sandbar willow, develops through transitional phases to a plains cottonwood dominated forest, and finally, in the absence of stand replacing floods, develops into a mixed deciduous forest that may contain the following tree species (in addition to aging cottonwoods): green ash, American elm, boxelder, bur oak, slippery elm, hackberry, American basswood, black walnut and eastern redcedar (Johnson 1950, Heckel 1963, Wilson 1970). Ecological studies along the Missouri River in central ND have documented a similar successional pattern ultimately resulting in a forest dominated by green ash, boxelder, American elm and bur oak (Johnson et al. 1976). (from Ode 2004). This was therefore modeled as a successional pathway to class D. Others have enough green ash that the next class, in this case class D, is dominated by green ash and Symphoricarpos occidentalis.

This class contains ranges from 51-150yrs and can then succeed to class D.

Minor flooding occurs every 10-20yrs. Minor flooding raises the level of the terrace. Because this is the last stage in this cottonwood portion of the system, this minor flooding was modeled as wind/weather stress, causing no transition. Major flooding occurs every approximate 200yrs, bringing this class back to class A. This was modeled as wind/weather stress.

Low severity fire was also modeled as it was in class B, causing no transition. Mixed severity fire was also included with the same probability as low severity, every 100yrs.

Optional 2 in this class represents erosional processes of river meandering that would bring this class eventually back to class A. The class/system will first be part of the river, but then will succeed to class A or a point bar state. This occurs with a frequency of several hundred years and was modeled at a frequency of 200yrs.

River meanders back and begins to cut away at the banks whereon a mature or old-growth stand of PODE3 exists and the living trees slowly are undercut and ultimately fall into the stream.

Beaver disturbance occurs in this class. The closer to the river, the more likely it is. It was modeled as "optional 1". Beaver activity is quite variable. It was modeled as occurring on one percent of this class on the landscape each year, maintaining this class.

Johnson (1992) states that older pioneer stands (40-80yrs. old) comprised 25% of the forest; that transitional forest (80-150yrs old) comprised 21% of the forested acreage and that equilibrium stands (dominated by green ash,elm, oak, etc.) (>150yrs old) comprised only seven percent of the forested acreage historically.

Class D **15 %**

Late Development 2 Closed

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model

Description

Indicator Species* and Canopy Position

FRPE	Middle
ACNE2	Middle
PODE3	Upper
ACSA2	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	71 %	100 %
Height	Tree 5.1m	Tree 25m
Tree Size Class	Large 21-33"DBH	

☐ Upper layer lifeform differs from dominant lifeform.

The trees are actually shorter as one moves west. Green ash and cottonwood in the central and western Dakotas are almost half the size

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of those in the Midwest.

The trees are actually shorter as one moves west. Green ash and cottonwood in the central and western Dakotas are almost half the size of those in the Midwest.

This class was based on R4NOFP class E. Found along the upper terrace that has been protected from most flood events, except for rare high intensity flooding. Species composition increases towards south and east within the region. Overstory species include hackberry, green ash, sycamore, black walnut and elm. Understory species include vines and poison ivy. Ulmus Americana is another indicator.

In the absence of stand replacing floods, this class is what has developed - a mixed deciduous forest that may contain the following tree species (in addition to aging cottonwoods): green ash, American elm, boxelder, bur oak, slippery elm, hackberry, American basswood, black walnut and eastern redcedar (Johnson 1950, Heckel 1963, Wilson 1965 and 1970, Lawry 1973), which is more prominent in the East but still present in the Dakotas. Ecological studies along the Missouri River in central ND have documented a similar successional pattern ultimately resulting in a forest dominated by green ash, boxelder, bur oak and American elm (Ode 2004).

Class D hackberry, slippery elm, basswood, bur oak and black walnut are present downstream from Yankton in the Dakotas. These species occur in central to eastern ND. In western ND (and probably much of western SD too) species are green ash, American elm, boxelder, eastern red cedar and Juniperus scopulorum.

Hansen et al. (1984) state that other dominants are Toxicodendron rydbergii and Elymus canadensis.

The FRPE/SYOC association is an edaphic climax on the floodplain adjacent to the Little Missouri River and its major tributaries. PODE currently dominates many stands but is no longer reproducing. It will be replaced by FRPE. The larger trees, some 6-7dm DBH are PODE3, but the young trees establishing in the stands are FRPE. JUSC is tallied with the tree species, although it's an understory species in the closed forest. Its current abundance is attributed to adequate light penetrating to the shrub and herb layers of the cmty as a result of wide spaceing of the old Populus. Along the Missouri River, in central ND, SE SD, and near Omaha, NE, PODE3 is a pioneer species and is replaced successionally by various combos of Fraxinus, Ulmus, Acer and Celtis. Among the grasses, CALO, ELCA and MURA are important (Hansen et al 1984).

The disturbances are those from R4NOFP: Major flooding events can bring this class back to A (0.004 probability - every 250yrs), modeled as wind/weather stress. Flooding events can also cause a transition back to C (0.005 probability - every 200yrs), modeled as wind/weather stress.

Mixed fire occurs every 50yrs but causes no transition.

Dominants of the green ash/western snowberry stands can resprout after fire. However, a very hot fire can kill the green ash (Lesica 2003), in which case it would probably become a stand of western snowberry-silver sagebrush-western wheatgrass (not modeled here).

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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: III**

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	500			0.002	10
Mixed	75			0.01333	63
Surface	175			0.00571	27
All Fires	48			0.02105	

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) beaver
- ☑ Other (optional 2) erosional processes of river meandering

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LANDFIRE Biophysical Setting Model

Biophysical Setting 3914770 Boreal Acidic Peatland 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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Vegetation Type

Wetlands/Riparian

Map Zone

39

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, trees grown through layering 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 15cm 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 greater than 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

This model for MZs 39 and 40 was adopted as-is from BpS 1477 from MZ41 created by Jim Reinartz, Christina Isenring and Randy Swaty and reviewed by Chris Dunham and Dave Cleland. No review was obtained for MZs 39 and 40, as we were told of the occurrence of this system at a late date, and it is thought to only occur on the outskirts of this mapzone on the MN edge.

A significant portion of the text for MZ41 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

Description

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.

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

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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 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

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.

Description

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

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.

Description

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,

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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

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 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

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.

Upper Layer Lifeform

☐ Herbaceous
☐ Shrub
☑ Tree

Fuel Model

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 1,000yrs. 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

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.

Upper Layer Lifeform

☑ Herbaceous
☐ Shrub
☐ Tree

Fuel Model

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.

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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

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 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		1000	0.0014	15
Mixed					
Surface	125		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 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
- [x] Other (optional 1) Flooding
- [ ] Other (optional 2)

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LANDFIRE Biophysical Setting Model

Biophysical Setting 3914820 Great Plains Prairie Pothole

☑ *This BPS is lumped with: 1493*

☐ *This BPS is split into multiple models: Don't map 1493. 1493 is probably wetter than 1482 potholes, but they'd intergrade within each other. Prairie potholes are driven by drought and have frequent drawdowns and go totally dry with regularity, whereas 1493 would always be wet. 1493 probably occurs from ECOMAP subsections 251Ba, 251Bb - 97 latitude east. However, there would be a combination of potholes versus 1493; therefore, we are lumping this into the potholes system.*

General Information

Contributors (also see the Comments field **Date** 6/1/2007

Modeler 1	Dave Ode	dave.ode@state.sd.us	**Reviewer**	modeler was reviewer
Modeler 2	Co-RL Elena Contreras (modeling fixes only)	econtreras@tnc.org	**Reviewer**	
Modeler 3			**Reviewer**	

Vegetation Type

Wetlands/Riparian

Map Zone

39

Model Zone

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

Dominant Species*

CAPE42	SCMA8
CAAT2	ELEOC
SPAN	PASM
SCAC3	CALA11

General Model Sources

☑ Literature
☑ Local Data
☑ Expert Estimate

Geographic Range

This type is found primarily in the glaciated northern Great Plains of the US and Canada. This system can be found throughout the northern Great Plains ranging from central IA northwest and northeast to southern Saskatchewan and Alberta, and extending west into north-central MT. It encompasses approximately 870,000 square km with approximately 80% of its range in southern Canada. It is also prevalent in ND, SD, and northern and western MN.

For MZs 39 and 40, it did occur prevalently throughout the zones in the eastern portions but not west of the Missouri River. The exception is in MT. It occurred from ECOMAP subsection 222Na down south through 251Bd and Bf and into IA; it is also in 331Ea south and east – so throughout the mapzones. However, it is not in eastern NE.

The Prairie Potholes do not exist in western SD, they do to an extent in western ND. The Prairie Potholes only exist in areas of the prairie that were affected by glaciation.

Biophysical Site Description

This BpS is dominated by depressional wetlands formed by glaciers scraping the landscape during the

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Pleistocene era. This system is typified by several classes of wetlands distinguished by changes in topography, soils and hydrology. Many of the basins within this system are closed basins and receive irregular inputs of water from their surroundings (groundwater and precipitation), and export water as groundwater. Hydrology of the potholes is complex. Precipitation and runoff from snowmelt are often the principal water sources, with groundwater inflow secondary. Evapotranspiration is the major water loss, with seepage loss secondary. Most of the wetlands and lakes contain water that is alkaline (pH >7.4). The concentration of dissolved solids result in water that ranges from fresh to extremely saline. There are more freshwater wetlands in a gradient going east through the Dakotas. The evapo-precipitation ratio affects the salinity, where it is more alkaline going west. The flora and vegetation of this system are a function of the topography, water regime, and salinity. In addition, because of periodic droughts and wet periods, many wetlands within this system may undergo vegetation cycles. This system includes elements of emergent marshes and wet, sedge meadows that develop into a pattern of concentric rings.

This system is dominated by closed basins and potholes that receive irregular inputs of water from the surroundings and export water as groundwater. The climate for the range of this system is characterized by mid-continental temperature and precipitation extremes. Snowmelt in the spring typically fills many of the potholes in examples of this system. The region in the range of this system is distinguished by a thin mantle of glacial drift with overlying stratified sedimentary rocks of the Mesozoic and Cenozoic ages; these form a glacial landscape of end moraines, stagnation moraines, outwash plains and lakeplains. The glacial drift ranges 30 to 120 m thick and forms steep to slight local relief with fine-grained, silty to clayey soils. Limestone, sandstone and shales predominant, and highly mineralized water can discharge from these rocks. The hydrology of this system is complex with salinity ranging from fresh to saline, and chemical characteristics varying seasonally and annually. Precipitation and snowmelt are the primary water sources with evapotranspiration being the source of major water loss.

Many or most of the potholes are depressions where glaciers deposited big chunks of ice in the ground. The ice melted leaving a depression that became ponds. Hydrologic regime and water quality (pH and conductivity) determine vegetation.

Vegetation Description

This system is comprised of different water permanence classes. Deep potholes are permanent. Some have seasonal water. Some have temporary flooded basins. Each has different set of associated vegetation. Deep marshes have cattails and bulrush. Shallow marshes in big basins, depending on salinity have sedges and prairie bulrush. There are also wet meadows and low prairies.

Some of the dominant species are Carex lanuginosa (woolly sedge) or Carex lasiocarpa and C. atherodes. C. lasiocarpa is found in fens while C. lanuginosa occurs in mineral soil of wetlands such as wet meadows and marshes.

Associations are:
Carex lasiocarpa or lanuginosa - Carex oligosperma / Sphagnum spp.; Schoenoplectus acutus (=Scirpus acutus) - (Schoenoplectus fluviatilis); Schoenoplectus maritimus (=Scirpus maritimus)- Schoenoplectus acutus (=Scirpus acutus) - (Triglochin maritima)
Carex oligosperma (in the east - not west of MN) - Carex lanuginosa; Schoenoplectus acutus - (Schoenoplectus tabernaemontani) Semipermanently; Schoenoplectus maritimus.

In big basins:
In the drawdown zone, species are Eleocharis acicularis, Rumex maritimus, Hordeum jubatum.

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In the wet meadow zone- Hordeum jubatum, Juncus balticus, Spartina pectinata
In the shallow marsh zone- Carex atherodes, Glyceria grandis, Eleocharis palustris Scirpus americanus, Scirpus maritimus
In the deep marsh zone- Typha latifolia, Scirpus acutus

Western wheatgrass and Eleocharis spp. are typical of the drier zones in MT.

The context in which these potholes exist is not always a grassland or xeric shrubland but can include aspen or mixed aspen/conifer communities as well.

Saline playa vegetation is the same as drawdown zone and shallow marsh zone vegetation for prairie potholes. Saline playas don't have deep marsh (cattail-bulrush) or open water vegetation like the deeper prairie potholes do.

Disturbance Description

Flooding is the primary natural dynamic influencing this system. Drought-flood cycling is the main disturbance and primary driver of successional change. Drought causes deep marsh to become shallow marsh, shallow marsh to become wet meadow etc. Snowmelt in the spring often floods this system and can cause the prominent potholes within the system to overflow. Greater than normal precipitation can flood out emergent vegetation and/or increase herbivory by animal species such as muskrats. This system can undergo periodic wet and droughty periods that can cause shifts in the vegetation. Vegetation zones are evident around the wet potholes throughout this system, and each zone responds to changing environmental conditions.

Draining and conversion to agriculture can also significantly impact this system. Much of the original extent of this system has been converted to cropland, and many remaining examples are under pressure to be drained.

Fire frequency would probably be much less than that in adjacent midgrass prairie because these systems stay fairly wet in at least 50% of years. However, it is probably less wet and in fewer years in the southern end of the MZ20. Fire would have little effect on the vegetation composition because nearly all the dominant plants are rhizomatous perennials that would not be damaged. A wet spring will usually mean the wetlands are wet, so fire will have minimal effect if the wetlands even burn. Brief spring rains followed by dry period will result in greatest fire potential. Fire probably occurs in drought years that have less relative humidity.

However, most of the wetlands in the ND Arrowwood NWR Complex contain heavy fuel loadings of emergent vegetation including bulrush, cattail and other vegetation that when cured, will support a fire even over the top of the water. During dry years, many of these areas will completely dry up, burning with moderate to high fire behavior characteristics (Arrowwood NWR Complex Fire Management Plan, 2001).

Activities of the wild bison (Bison bison), which was extirpated from the Prairie Pothole Region of the Dakotas in the 19th century, had a major biotic influence on prairie wetlands in pristine times. Unfortunately, there is no documentation of how wetlands were impacted by the feeding, drinking, dusting or other activities of millions of these huge, shaggy beasts as they roamed the prairies. Other grassland mammals extirpated from the region are the grizzly bear (Ursus arctos), kit fox (Vulpes velox) and plains wolf (Canis lupus). These carnivores probably made only minor use of prairie wetlands (Kantrud et al. 1989).

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Uncounted numbers of wapiti (Cervus elephus) and pronghorn (Antilocapra americana) and smaller numbers of mule deer (Odocoileus hemionus), the only other large herbivores of open grasslands, once inhabited the region and undoubtedly used the wetlands, at least for drinking. These three species are still found in small numbers in the region. Also nearly extirpated from the prairie region are the river otter (Lutra canadensis), mountain lion (Felis concolor), lynx (F. lynx) and bobcat (F. rufus). Although once distributed throughout the region, it is unlikely that any of these species were strongly associated with the wetlands dealt with in this report (Kantrud et al. 1989).

Potholes are a sort of subclass within depressional wetlands; therefore, the model from the Depressional Wetland system is used as a starting point for this BpS.

Adjacency or Identification Concerns

This system is within the tallgrass prairie matrix. Mixedgrass prairie can also be adjacent.

Much of the original extent of this system has been converted to agriculture, and only approximately 40-50% of the system remains undrained (NatureServe 2007). Many wetlands today have been drained and cropped; federal policy has slowed this process.

Estimates of wetlands lost in North and SD are 49% and 35% respectively (Dahl 1990). Remaining wetlands are often highly degraded (i.e., sediment-filled, invaded by non-native plants and poor water quality due to agricultural runoff).

About half of the original potholes in the Dakotas have been destroyed (60% in ND and 40% in SD; Tiner 1984). Over half were altered by agriculture, irrigation, and flood control projects (http://www.fws.gov/nwi/Pubs_Reports/isolated/report_files/2_section/overview.htm).

Also, because of hydrological manipulations of water systems including potholes and riparian systems, the water movement on the landscape occurs in a modified manner than in pristine times. Wetlands are often dominated by monotypic stands of reed canary grass or narrow-leaf and/or hybrid cattail.

In terms of differences today versus the historic system – exotic cattails and hybrids of have created monotypic stands in the semi-permanent basins, instead of being interspersed within. There would have been less continuous vegetation and therefore fire historically versus now. There were patches, but now there are exotic cattails forming uniform monocultures throughout the deep marsh or open water zone, and so there is more fire today (Dave Ode, pers comm.). If there is more open water, it is thought that that might cause more of a move to solid cattails.

A large proportion of temporary wetlands are cropped. They're shallow, just wet spots. Drainage and filling is occurring. The deep ones get drained. SD and ND do still have many potholes, however.

Today there are also small wetlands that are more integrated now because of drainage. Smaller potholes are being drained into the nearest big wetland or lake. This increases the flood frequency in larger basins. Drainage has altered the hydrology of drained and receiving basins.

In MZ30 these wetlands are surrounded by mixed-grass prairie or cropland. In MZ20, they can be surrounded by aspen or fescue (foothills) prairie. In MZs 39 and 40, this BpS is surrounded by tallgrass prairie in the eastern Dakotas and mixedgrass prairie in the central Dakotas and west. The context in

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which these potholes exist is not always a grassland or xeric shrubland but can include aspen or mixed aspen/conifer communities as well.

This system could be confused with Western Great Plains Depressional Wetland System, and indeed, some shallow, saline prairie potholes have nearly identical vegetation. It may also even be said that potholes are a sort of subclass within depressional wetlands, they just have a unique origin, occurring within glaciated terrain where ice-blocks have melted leaving kettle holes (depressions) of various dimensions. Also though the 1495 wetlands systems could probably be just a subsection of the prairie potholes 1482. It might even be that the variability of the prairie potholes encompasses the wetland system 1495. The 1495 wetlands systems would be the unglaciated semi-arid system versus potholes which would be glacial sub-humid.

Saline playa vegetation is the same as drawdown zone and shallow marsh zone vegetation for prairie potholes. Saline playas don't have deep marsh (cattail-bulrush) or open water vegetation like the deeper prairie potholes do. However, the potholes are also different from wetlands in that potholes are typically connected to each other in a broad spatial/temporal fashion. In wet years and wet seasons, and in individual basins, they often have both surface and groundwater connections.

It is also unclear as to where one would draw the line between a lake and a pothole when describing deep potholes. These systems are very variable. There are huge basins such as in Preston and Whitewood, where there were huge cattail marshes flooded in the 1980s and are now lakes; they got into the wet cycle and became lakes and still have not returned.

There was also some debate in MZs 39 and 40 as to whether or not potholes should be lumped into the tallgrass systems. It was decided that they would be split out. When there is water, it is a system. Drought converts the aquatic system to terrestrial. The system goes in and out of existence based on weather patterns. There is also a temporal shift where potholes might go out of existence. Permanent wetlands are further east, but further northwest through to western ND, they go in and out of this pothole state.

Poa pratensis, Poa palustris and Kochia scoparia are common exotics.

In prairie wetlands, disruption of natural processes such as fire has led to domination by robust, emergent plants, particularly in the prairie pothole region. Cattail, once rare on the Great Plains, has spread across thousands of prairie wetlands, as has purple loosestrife, a species native to Europe which is now threatening waterways across the United States (US Congress, Office of Technology Assessment 1993; Malecki and Blossey 1994). In the past, climate, fire and grazing controlled the diversity and abundance of vegetation in northern prairie wetlands (http://www.npwrc.usgs.gov/resource/habitat/grlands/landmgt.htm).

More is known about the effects of grazing than fire. Nodal rooting, or underground branching and unpalatability are evident evolutionary responses of wetland plants to grazing. Under certain conditions grazing can increase species diversity and the development of intricate patterns and sharp boundaries among prairie wetland plant communities (Bakker and Ruyter 1981).

Also - herbaceous wetlands BpS 1493 are being combined into this system. 1493 is probably wetter than 1482 potholes, but they'd intergrade within each other. Prairie potholes are driven by drought and have frequent drawdowns and go totally dry with regularity, whereas 1493 would always be wet. BpS 1493 probably occurs from ECOMAP subsections 251Ba, 251Bb - 97 latitude east. However, there would be a combination of potholes versus 1493; therefore, we are lumping this into the potholes system.

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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

Native Uncharacteristic Conditions

Vegetation may be more productive in wetlands polluted by agricultural fertilizers.

Scale Description

Prairie wetlands can vary in size from a couple of acres to hundreds of acres.

Potholes are generally not connected with each other.

Issues/Problems

Potholes are a sort of subclass within depressional wetlands; therefore, the model from the Depressional Wetland system is used for this BpS.

Comments

This model for MZs 39 and 40 was adapted from the model from the same BpS 1482 from MZs 20 and 30 created by Peter Lesica peter.lesica@mso.umt.edu, modified by MZ30 regional lead and reviewed by Kathy Roche kroche@fs.fed.us. For MZs 39 and 40, co-regional lead, Elena Contreras, made model implementations and fixes.

The model for MZ30 was created using the NatureServe original description, some comments and model from BpS 1495 Western Great Plains Depressional Wetland System for the successional classes and model.

Vegetation Classes

Class A **40 %**

Early Development 1 All Structure

Upper Layer Lifeform

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

Fuel Model

Indicator Species* and Canopy Position

CALA11	Upper
CAAT2	Upper
ELEOC	Upper
PASM	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	30 %
Height	Herb 0m	Herb 1.0m
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform.

Description

This class is dominated by resprouts and seedlings of grasses and post-fire associated forbs with low to medium height with variable canopy cover. In the deep marsh, it is 50% vegetated and 50% open water. For previous mapzones such as 30 or 20, previous modelers might have been thinking that the low vegetative cover should be modeled because part was open water. However, for MZs 39 and 40, there is a different view as to how this should be modeled. In shallow potholes, there is high vegetative cover. If there is deep water, there would actually be a zone of cattails surrounding. If the basin is flooded, this drowns out all vegetation. When it drops down, it will go without vegetation until the appropriate environment starts, and then vegetation will generate (although currently cattail will regenerate creating a monoculture – which is a different endpoint than that which would have happened historically). The flood event kills deep marsh vegetation, then the water recedes and almost has to go down to nothing for the vegetation to become re-established. With seedling established on wet areas and not standing water in the basin, emergent plants will grow. Water will then return, and then the pothole will be an interspersed emergent vegetation and open water mosaic. Over time, it will become denser with vegetation.

The smaller the basin, probably the quicker the cycling might occur. It is thought that perhaps as little as seven years could cause a move to class B.

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Drought will affect large amounts of the area.

The split of 35-40% in A and 60-65% in B might be okay historically. However, the potholes in the western areas will have a higher frequency of being dry, so there might be more area in class A, whereas in the east, there will be a higher frequency of being wet, so there might be more in class B.

For MZs 39 and 40, class A was modeled to last for approximately 10yrs. Class B would be back in just a few years following a fire. Fire would cause little change in species composition except possible a temporary decline in Puccinellia and Hordeum (bunch grasses).

Native grazing and herbivory could be heavy (10% of this class each year).

Replacement fire occurs every 50yrs, which is somewhat longer than the MFRI of an adjacent grassland community. Since this is a wetland community, it is thought that fire would impact the landscape much less frequently. The fire frequency would vary dependent on type of pothole. Temporary wetlands/potholes burned more frequently – probably as often as a grassland since they only had water for a short period and then they dry up. The larger ones probably have water most of the time and would not burn because they would be full of water. Also, after a flood, the flood might have killed the vegetation and then the fire frequency wouldn't be high, because there would be no vegetation for fuels. (For example, around Miller, SD, big basins flooded, and now they are dry because no more vegetation is there – Dave Ode, pers comm.). There would only be a few phases where the potholes would be susceptible to fire – for instance, when there is vegetation and when it is dry and during drought.

Drought was therefore also modeled as wind/weather stress occurring with the same frequency as fire and bringing this class back to the beginning stage.

Major flooding was modeled as "option1" occurring with a probability of 0.01 (occurs across all potholes every 100yrs) bringing this class all the way back to the beginning.

Regular flooding was modeled as "option2" occurring with a probability of 0.02 (occurs across all potholes every 50yrs) but not causing a transition.

Class B **60 %**

Mid Development 1 Closed

Upper Layer Lifeform

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

Fuel Model

Indicator Species* and Canopy Position

CALA11	Upper
CAAT2	Upper
ELEOC	Upper
PASM	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	31 %	100 %
Height	Herb 0m	Herb >1.1m
Tree Size Class	None	

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

Scattered shrubs may be present.

Description

This class has >30% herb and shrub cover combined. Cover can be up to 100% in shallow potholes.

Native grazing and herbivory could be heavy (20% of this class each year).

Replacement fire occurs every 50yrs, which is somewhat longer than the MFRI of an adjacent grassland community. Since this is a wetland community, it is thought that fire would impact the landscape much less

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frequently. The fire frequency would vary dependent on type of pothole. Temporary wetlands/potholes burned more frequently – probably as often as a grassland since they only had water for a short period and then they dry up. The larger ones probably have water most of the time and would not burn because they would be full of water. Also, after a flood, the flood might have killed the vegetation and then the fire frequency wouldn't be high, because there would be no vegetation for fuels. (For example, around Miller, SD, big basins flooded, and now they are dry because no more vegetation is there – Dave Ode, pers comm.). There would only be a few phases where the potholes would be susceptible to fire – for instance, when there is vegetation and when it is dry and during drought.

Drought was therefore also modeled as wind/weather stress occurring with the same frequency as fire and bringing this class back to the beginning stage.

Major flooding was modeled as "option1" occurring with a probability of 0.01 (occurs across all potholes every 100yrs) bringing this class all the way back to the beginning.

Regular flooding was modeled as "option2" occurring with a probability of 0.02 (occurs across all potholes every 50yrs) but not causing a transition.

Class C **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 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

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:** IV

Historical Fire Size (acres)

Avg
Min
Max

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	50	10	100	0.02	100
Mixed					
Surface					
All Fires	50			0.02002	

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
- [x] Other (optional 1) major flooding
- [x] Other (optional 2) regular flooding

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LANDFIRE Biophysical Setting Model

Biophysical Setting 3914950 Western Great Plains Depressional Wetland Systems

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

General Information

Contributors (also see the Comments field **Date** 6/1/2007

Modeler 1	Dave Ode	dave.ode@state.sd.us	**Reviewer**	modeler was reviewer	
Modeler 2	Co-RL Elena Contreras (modeling fixes only)	econtreras@tnc.org	**Reviewer**	Tom Bragg	tbragg@mail.unomaha.edu
Modeler 3			**Reviewer**		

Vegetation Type
Upland Grassland/Herbaceous

Map Zone
39

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

Dominant Species*

PASM	ELPA3
	JUBA
HOJU	PUCCI
ELAC	POAMS

General Model Sources
☑ Literature
☑ Local Data
☑ Expert Estimate

Geographic Range

This systems group occurs across the western Great Plains from ND and KS west to MT and south to TX.

This system occurs in ECOMAP sections 331F and subsection 332Bd. It occurs in northern part of MZ31 and west of the sandhills, subsections 331Fs and 331Fh. There might be some of this system in subsection 332Bd and other areas of MZs 39 and 40.

These probably do also occur in the Dakotas.

This includes wetlands in the Sandhills.

Biophysical Site Description

These are semi-arid unglaciated depressional wetlands. For MZ 30, 39 and 40, this system includes wetlands that form in upland and lowland depressions across the western Great Plains. Isolated depression wetlands (including playa lakes) form in small basins within upland landscapes that are rarely linked to outside groundwater sources and do not have an extensive watershed. Open depression wetlands form in lowlands, including lake borders and stream margins, that have more open basins, usually have a larger watershed, and a permanent water source throughout most of the year (except during exceptional drought years). The isolated depressions are typified by the presence of an impermeable layer such as a dense clay, hydric soil and are usually recharged by rainwater and nearby runoff (Nature Serve 2007).

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Isolated ponds and lakes can experience periodic drawdowns during drier seasons and years and are often replenished by spring rains. In areas of saline soils, both isolated and open depressions will be more brackish, with associated vegetation differences. Salt encrustations can occur on the surface in some of these depressions. Soils are severely affected by the saline conditions and have poor structure.

The system includes submergent and emergent marshes, and associated wet meadows and wet prairies. These types can also drift into stream margins that are more permanently wet and linked directly to basin via groundwater flow from/into the pond or lake. Isolated ponds and lakes can experience periodic drawdowns during drier seasons and years and are often replenished by spring rains.

Vegetation Description

In MZs 31, 39 and 40, Eleocharis spp., Hordeum jubatum and common forbs such as Coreopsis tinctoria, Symphyotrichum subulatum (= Aster subulatus) and Polygonum pensylvanicum (= Polygonum bicorne) are common vegetation in the wetter and deeper depressions, while Pascopyrum smithii and Buchloe dactyloides are more common in shallow depressions in rangeland. Open depression wetlands include submergent and emergent marshes with Typha spp. and Schoenoplectus spp., and associated wet meadows and wet prairies. In areas of saline soils, both isolated and open depressions will be more brackish, with associated vegetation differences. Salt encrustations can occur on the surface in some depressions, and the soils are severely affected and have poor structure. Species that typify these systems are salt-tolerant and halophytic species such as Distichlis spicata, Sporobolus airoides and Hordeum jubatum. Other commonly occurring taxa include Puccinellia nuttalliana, Salicornia rubra, Suaeda calceoliformis, Spartina spp. and shrubs such as Sarcobatus vermiculatus and Krascheninnikovia lanata (NatureServe 2007).

In MZ20, vegetation is dominated by sparse to dense cover of graminoids, up to one meter tall, although typically 0.6m or shorter. Pascopyrum smithii usually dominates, with Distichlis spicata, Hordeum jubatum, Eleocharis acicularis or Eleocharis palustris complex almost co-dominant. Juncus balticus will be present in areas where water stands for longer after a storm or where flooding occurs. Other graminoids include Puccinellia nuttalliana, Bouteloua gracilis, Koeleria macrantha and Hesperostipa comata (HECO questionable, since it prefers sandy soils and this type is developed on clay soils). Spartina gracilis has been documented in MZ20 but only in limited areas. Woody plants are rare, except for occasional Gutierrezia sarothrae, Artemisia frigida, Artemisia cana or Symphoricarpos occidentalis. Sarcobatus vermiculatus and Basin wildrye (Elymus cinereus) can also be associated with saline playa vegetation in MT, although they are probably not nearly as common as the listed dominants.

In MZ31, the PASM/ELXE (ELXE is a component of the ELPA3 complex) complex dominate diagnostically. That is the complex that is only in here and not generally in prairie potholes. Hordeum jubatum and Polygonum coccineum is also diagnostic, although those might occur in prairie potholes too.

Disturbance Description

Flooding, grazing, drought and fire represent significant disturbances to this group of ecosystems.

Fire: Plant communities providing saltgrass habitat are diverse and exhibit a wide range of fire frequencies. Saltgrass is found in desert shrub communities that have fire return intervals of <35yrs to over 100yrs (Hauser 2006). The saltgrass habitat, however, is not a dominant component in MZ39 in central and southern SD in MZ31. Some saltgrass communities occur rarely in western and central southern NE (i.e. Salt Creek in the vicinity of Lincoln, NE). Other depressional wetlands seem unlikely to be sufficiently frequent to require a separate section. Therefore, a different fire return interval is being modeled.

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Depending on alkalinity, fire frequency would vary – high alkalinity would prevent sufficient accumulation of fuel much of the time, especially where the graminoid community is sparce or absent.

At least in NE (the southern portion of the zones), fire frequency might have been similar to the surrounding prairie which is more likely to have been every 3-4yrs (Bragg 1995).

Historical fire size is dependent on the surrounding vegetation and the size of the depressional wetland. Fire could burn an entire small area if fuel occurred across it. Generally, however, fires would burn less than the entire depression if water or bare soil prevented a fire from sweeping across the center. Fire size would vary from less than a hectare to several hectare. The frequency of burning would largely mimic the MFRI of the surrounding prairie unless the vegetation of the depressional wetland does not support graminoids that approximate the fuels of the surrounding vegetation in which case the MFRI would be longer (Collins and Uno 1983).

Hydrology: Hydrology affects this system. However, it is dry for more years than wet. The flooding frequency would put this into a different system than the surrounding grassland. It floods often enough with predictable regularity. It usually behaves like the surrounding grassland in terms of fire. It would experience more fire than other wet communities, such as prairie potholes, because it is drier. The small wetlands would burn more frequently than the large ones, since the large ones might have more bare ground or be deeper.

Drought occurs in this system, and there are regular wet/dry cycles. This system is either all wet or all dry, which is simpler than how the prairie pothole system functions.

Grazing: Grazing might have had an effect on this system. There would be trampling disturbance due to the softness of the soil. Trampling would be more severe than the surrounding grassland because of the wetness. Grazing by native ungulates such as buffalo and antelope can affect non-saline ecosystems where the grazers may be particularly likely to congregate at any time of the year but particularly during droughts. Non-alkaline sites may be more affected by grazing that alkaline sites.

Return interval for fire could be extended by ungulate grazing if ungulates graze the depressions.

Other: Episodic disturbance is caused by insect infestation (grasshoppers, range caterpillars, Mormon crickets). This was not modeled.

Adjacency or Identification Concerns

In MZs 31 and 39 in the Great Plains, this system is primarily adjacent to mixedgrass prairie or riparian zones or badlands. In MZs 31, 39 and 40 they might also be adjacent to or embedded within tallgrass prairie.

This system could be confused with 1482 Great Plains Prairie Potholes, though this system is simpler than the prairie potholes; it is not as variable as BpS 1482 . This might also be distinguished from the Sandhill wetlands/lakes, which are formed in the bottom of sand dunes, directly connected to groundwater and very permanent and rarely go dry and are not as alkaline as these wetlands.

These 1495 wetlands systems would just be in the northern part of MZ31. Some portions of MZs 39 and 40 would be prairie potholes BpS 1482 in the glaciated portions. This wetland system is probably just a

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subsection of the prairie potholes 1482. It might even be that the variability of the prairie potholes encompasses this wetland system 1495. This system would be the semi-arid system versus potholes which would be glacial sub-humid. These are the unglaciated semi-arid wetlands.

This 1495 wetlands system in the Dakotas also has a more frequent fire return interval than prairie potholes, since this wetland system is drier.

The Nebraska Sandhill "wetlands" or lakes differ from other depressional wetlands; however, this 1495 description focuses on combining several small ecosystems (i.e. the various types of depressional wetlands) which (1) individually are very small in extent and (2) typically are embedded within a larger surrounding plant community that would dictate the general fire regime for the region. For the small wetlands in MZs 31, 39 and 40, depressional wetlands do occur but generally do not constitute a substantive portion of the total landscape as to warrant separation. Sandhills wetlands are very small; some should be included within this BpS 1495 Western Great Plains Depressional Wetland Systems, but some should just be lumped with an adjacent system such as tallgrass prairie.

The rainwater basins of NE are mostly lowland prairie. They are connected to groundwater or associated with Platte River water. However, these are relatively small ecosystems and are not modeled separately but should rather just be a part of their adjacent system. They are generally embedded in the larger landscape.

These wetlands are affected by hydrological changes, grazing and conversion to agricultural use. Species richness can vary considerably among individual examples and is especially influenced by adjacent land use. Agriculture is often adjacent and may provide nutrient and herbicide runoff (NatureServe 2007).

This system might not be that departed from how it appeared historically. There are not many exotics. It has been plowed and drained some. And it probably burns less frequently than its historical occurrence.

For saline wetlands, other than losses to human activity, the systems may be somewhat similar to historic conditions since they were probably not substantively affected by biotic factors. For non-saline ecosystems, differences could be substantial with greater woody plant cover, greater disturbance by cattle, and concomitant changes in composition and erosion.

In the southeast part of MZ31 and in NE, there is a current problem with reed canary grass (PHAR).

Since the early 1900s, fire has been excluded and nonnative species such as Japanese brome (Bromus japonicus), smooth brome, Kentucky bluegrass, crested wheatgrass (Agropyron cristatum) and Canada thistle (Cirsium arvense) have taken a strong hold in the Great Plains mixedgrass prairies where saltgrass occurs (Hauser 2006).

Non-native invasive species (e.g. Bromus inermis and B. japonicus) may be confused with native successional species although, more likely, these species will have changed the successional dynamics both with respect to the dominant vegetation and to the likelihood of fire (e.g. if there is a greater cover of grasses).

Bromus japonicus is the most likely exotic to become common in this type.

Native Uncharacteristic Conditions

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Scale Description

In SD, this system is mostly 20-100ac, and maybe as small as ten acres.

Historical fire size is very dependent upon the surrounding vegetation.

Issues/Problems

There is very little research on this system and its dynamics especially in the Great Plains area.

Comments

This model for MZs 31, 39 and 40 was adapted from the model from the same BpS 1495 from MZs 29 and 30 reviewed by Peter Lesica peter.lesica@mso.umt.edu and Kathy Roche kroche@fs.fed.us. For MZs 31, 39 and 40, quantitative and descriptive changes were made due to a different understanding and to better reflect these systems in the Great Plains; this included adding more frequent fire. Co-regional lead Elena Contreras also added in descriptions from NatureServe and made the quantitative changes to the model according to modeler/reviewer suggestions.

The model for MZs 29 and 30 was adopted as-is from the same BpS from MZ20 which was reviewed by Linda Vance.

The model for MZ20 was adapted from the draft model for the same BpS from MZ22 created by Kathy Roche and Carolyn Meyer. Descriptive changes were made to reflect the system within MZ20 and to more fully describe the system.

This model for MZ22 was adapted from the model from BpS 1149 in MZ28, which was an adjacent western Great Plains shortgrass prairie model. Quantitative and descriptive changes were made, and this is in essence a new model. Therefore, comments and modeler and reviewer names from 281149 have been removed.

Vegetation Classes

Class A 45 %

Early Development 1 All Structure

Upper Layer Lifeform

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

Fuel Model 1

Indicator Species* and Canopy Position

PASM	Upper
	Upper
HOJU	Upper
ELAC	Upper

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	50 %
Height	Herb 0m	Herb 1.0m
Tree Size Class	None	

- [ ] Upper layer lifeform differs from dominant lifeform.

Description

This class is dominated by resprouts and seedlings of grasses and post-fire associated forbs of low to medium height with variable canopy cover. This class revegetates quickly and fills up, and annuals come in quickly after disturbance (thus the 0-50% cover, unlike the models from previous mapzones).

Rhizomatous perennials are in this class. The system can be flooded out, and when the water goes down, there is bare soil. But then it is rapidly colonized by HOJU or other annuals. Then in a few years (Eliocharis persists in the seed bank and sprouts up), western wheatgrass comes in over time, and this becomes more like a grassland, until it gets flooded again. This class would persist for probably only about five years, as vegetation establishes quickly in the Dakotas and NE. It might stay as open water for a short while, but once

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it gets out of the open water stage, it would go to a developed grassy stage quickly.

The only way this class would persist in this class longer would be if there was some fairly heavy livestock grazing. Class B would be back in just a few years following a fire.

Fire would cause little change in species composition except possible a temporary decline in Puccinellia and Hordeum (bunchgrasses).

Native grazing and herbivory could be heavy (10% of this class each year).

Replacement fire occurs with a frequency similar to that in the adjacent grassland communities and more frequent than that for prairie potholes, because this system is drier more often than prairie potholes. Return interval was therefore modeled as occurring every 20yrs, since prairie potholes were modeled at a 50yr return interval and grasslands at 5-10yrs. It is thought that it would take longer for fire to rotate among all of the wetlands than the grassland, however, which is why a less frequent interval than grassland was chosen. (Previous mapzones modeled a less frequent return interval; however, that thinking was rejected for MZs 31, 39 and 40).

Regular flooding and drought was also modeled as wind/weather stress and optional 1, respectively, as occurring every five years combined.

Class B **55 %**

Mid Development 1 Closed

Upper Layer Lifeform

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

Fuel Model 1

Indicator Species* and Canopy Position

PASM	Upper
	Upper
ELAC	Upper
HOJU	Upper

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	51 %	100 %
Height	Herb 0m	Herb 1.0m
Tree Size Class	None	

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

Scattered shrubs may be present.

Description

This class establishes quickly after disturbance. Other species in MZs 31, 39 and 40 could include Schoenoplectus (bulrush) or Typha.

Flooding could take this class back to class A. This was modeled with a return interval of 10yrs.

Drought also occurs with a modeled return interval of every 10yrs.

Native grazing and herbivory could be heavy (20% of this class each year).

Replacement fire occurs with a frequency similar to that in the adjacent grassland communities and more frequent than that for prairie potholes, because this system is drier more often than prairie potholes. Return interval was therefore modeled as occurring every 20yrs, since prairie potholes were modeled at a 50yr return interval and grasslands at five to ten years. It is thought that it would take longer for fire to rotate among all of the wetlands than the grassland, however, which is why a less frequent interval than grassland was chosen.

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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

Class C 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 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 10
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	20	10	100	0.05	100
Mixed					
Surface					
All Fires	20			0.05002	

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) drought
- ☐ Other (optional 2)

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