

LANDFIRE Biophysical Setting Model

Biophysical Setting 4014200

Northern Tallgrass Prairie

☒ This BPS is lumped with: 1421, 1488

☐ This BPS is split into multiple models: Don't map 1421. Just include it in here.

For 1488, don't map it. 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

Modeler 2 Cami Dixon
Cami_Dixon@fws.gov

Reviewer modelers re-reviewed

Modeler 3 Kyle Kelsey
Kyle_Kelsey@fws.gov

Reviewer Gary Willson
gwillson2@unlnotes.unl.edu

Vegetation Type

Upland
Grassland/Herbaceous

Dominant Species

ANGE
PAVI2

Map Zone

40

Model Zone

☐ Alaska
☐ California

☒ Northern Plains
☐ N-Cent. Rockies

General Model Sources

☒ Literature

☐ Local Data

☒ Expert Estimate

ELTRS

SPHE

HESP11

☐
☐ Great Basin
☐ Great Lakes
☐ Hawaii
☐ Northeast

☐
☐ Pacific Northwest
☐ South Central
☐ Southeast
☐ S. Appalachians
☐ Southwest

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 mapzones 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 17-36 inches.

**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 severity.

Vegetation Description

Grassland groupings of the Northern Tallgrass Prairie are the bluestem prairie from southern Manitoba 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 FRI 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, FRI, 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, 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

****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 severity.

woody plant removal, etc.) much of the Northern Tallgrass Prairie could succeed to shrubland or woodland.

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 1% 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 FRI 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

****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 severity.**

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 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

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 North Dakota, 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 Northern Tallgrass Prairie - 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

****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 severity.

This model for MZs 39 and 40 was adapted from the Rapid Assessment model: R4PRTGn Northern Tallgrass Prairie created by Jim Drake jim_drake@naturereserve.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 <u>Upper Layer Lifeform</u> ☒ Herbaceous ☐ Shrub ☐ Tree <u>Fuel Model</u> 1	<u>Indicator Species and Canopy Position</u> ANGE Upper PAVI2 Upper HESP11 Upper SONU2 Upper	<u>Structure Data (for upper layer lifeform)</u> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th></th> <th style="text-align: center;">Min</th> <th style="text-align: center;">Max</th> </tr> </thead> <tbody> <tr> <td>Cover</td> <td style="text-align: center;">0 %</td> <td style="text-align: center;">40 %</td> </tr> <tr> <td>Height</td> <td style="text-align: center;">Herb 0m</td> <td style="text-align: center;">Herb >1.1m</td> </tr> <tr> <td>Tree Size Class</td> <td colspan="2"></td> </tr> </tbody> </table> ☐ Upper layer lifeform differs from dominant lifeform.		Min	Max	Cover	0 %	40 %	Height	Herb 0m	Herb >1.1m	Tree Size Class		
	Min	Max												
Cover	0 %	40 %												
Height	Herb 0m	Herb >1.1m												
Tree Size Class														

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 3 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 stages (1) immediately after the fire (until fuel accumulates) and 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 map zone 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 Tallgrass Prairie (3-4yrs in the Central Tallgrass Prairie). Further, fires in this 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).

**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 severity.

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 class A or B remain on the landscape today; most is class C or D.

Grazing was modeled to occur on 60% of this class each year.

Class B 44 %		<u>Indicator Species and Canopy Position</u>	<u>Structure Data (for upper layer lifeform)</u>												
Mid Development 1 Closed		ANGE	<table><tr><td></td><td>Min</td><td>Max</td></tr><tr><td>Cover</td><td>41 %</td><td>100 %</td></tr><tr><td>Height</td><td>Herb 0m</td><td>Herb >1.1m</td></tr><tr><td>Tree Size Class</td><td colspan="2"></td></tr></table>		Min	Max	Cover	41 %	100 %	Height	Herb 0m	Herb >1.1m	Tree Size Class		
	Min	Max													
Cover	41 %	100 %													
Height	Herb 0m	Herb >1.1m													
Tree Size Class															
<u>Upper Layer Lifeform</u>		Upper	☐ Upper layer lifeform differs from dominant lifeform.												
☒ Herbaceous		PAVI2													
☐ Shrub		Upper													
☐ Tree	<u>Fuel Model</u>	SONU2													
	3	Upper													
		HESP11													
Description		Upper													

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 class A based on fuel model (3 for class B vs 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.

**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 severity.

Class C 5 %

Late Development 1 Closed

Upper Layer Lifeform

- ☐ Herbaceous
☒ Shrub
☐ Tree

Fuel Model

1

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 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 class A.

Class D 2 %

Late Development 1 All Structures

Upper Layer Lifeform

- ☐ Herbaceous
☐ Shrub
☒ Tree

Fuel Model

3

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 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

**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 severity.

bur oak and quaking aspen are small in size and make up 2-5% of the class; dogwood might also be present. 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

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 3500
Min 10
Max 100000

Sources of Fire Regime Data

- ☒ Literature
☐ Local Data
☒ Expert Estimate

Additional Disturbances Modeled

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

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 inverse 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.

References

Bragg, T.B. 1995. Climate, soils and fire: The physical environment of North American grasslands. Pages 49-81 In *The Changing Prairie*, K. Keeler and A. Joern, editors. Oxford University Press, New York.

Carpenter, J.R. 1940. The Grassland Biome. *Ecological Monographs* 10(4): 617-684.

Isenberg, A.C. 2000. *The Destruction of the Bison: An Environmental History, 1750-1920*. Cambridge Univ. Press, New York, NY.

**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 severity.

NatureServe. 2007. International Ecological Classification Standard: Terrestrial Ecological Classifications. NatureServe Central Databases. Arlington, VA, U.S.A. Data current as of 10 February 2007.

Rowe, J.S. 1969. Lightning fires in Saskatchewan grasslands. Canadian Field Naturalist. 83: 317-327.

Samson, F.B., F.L. Knopf, and W.R. Ostlie. 1998. Grasslands. Pages 437-472 in M.J. Mac, P.A. Opler, C.E. Puckett Haecker, and P.D. Doran, eds. Status and Trends of the Nation's Biological Resources, Vol. 2. Jamestown, ND.

Severson, K.E. and C.H. Sieg. 2006. The nature of eastern North Dakota: Pre-1880 historical ecology. North Dakota Institute for Regional Studies, North Dakota State University.

Smeins, F.E. and D.E. Olsen. 1967. Species Composition and Production of a Native Minnesota Tall Grass Prairie. American Midland Naturalist 84(2): 398-410.

Weaver, J.E. 1954. North American Prairie. Johnson Publishing Company, Lincoln, NE. 348 pp.

Wright, H.A. and A.W. Bailey. 1982. Fire Ecology: United States and Canada. John Wiley and Sons, New York. 501 pp.

**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 severity.