**11480**

**Western Great Plains Sand Prairie**

BpS Model/Description Version: Aug. 2020

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**Vegetation Type**

Herbaceous

**Map Zones**

31, 38

**Geographic Range**

Nebraska Sandhills Prairie is found in central and western Nebraska, southcentral South Dakota, covering approximately 5.5 million ha (Bleed and Flowerday, 1990).

**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 farther 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.

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 Nebraska and South Dakota (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 have 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).

**BpS Dominant and Indicator Species**

Species names are from the NRCS PLANTS database. Check species codes at http://plants.usda.gov.

**Disturbance Description**

Grazing, fire, 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 grasshoppers are present in large numbers, however. They were not modeled due to lack of data.

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, mixedgrass 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; 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 would 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 percentage 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, personal communication).

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 ~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˚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, fires were 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, 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 are 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 led to the development of blowouts, making it difficult for vegetation to reestablish 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).

More recent scientific evidence counters previous expectations and regional concerns that high-intensity fires during drought in Sandhills prairie will result in blowouts or destabilized sand dunes. A recent study following the worst drought on modern record observed no destabilization following fire (Arterburn et al. 2017). Plant biomass and composition were indistinguishable from prairie that was not burned within 2yrs following fire (Arterburn et al. 2017). In fact, evidence shows that roots of perennial vegetation stabilize dunes despite a lack of above-ground biomass and that grasses quickly recover following fire in this system, even under severe drought conditions (Arterburn 2017; Morrison et al. 1986; Bragg 1998; Volesky and Connot 2000; Schmeisser et al. 2009).

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.

**Fire Frequency**

Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is the central tendency modeled. Percent of all fires is the percent of all fires modeled in that severity class. Minimum and Maximum FIs show the relative range of fire intervals as estimated by model contributors, if known.

**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.

Between 1984 and 2014, 257 wildfires occurred within the Western Great Plains Sand Prairie map zones (MZs) 31 and 38 (MTBS 2016). The largest wildfire was ~89,000ac in size, with a mean fire size of ~5,400ac (MTBS 2016).

**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 in 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 Nebraska. 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 northcentral Nebraska 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 much subirrigated area and is rather tallgrass or mixedgrass. Likewise, central Nebraska 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 vegetation and therefore should not be classified as Sandhills but rather a grass system (John Ortmann, TNC, personal communication). (Current conditions in Loess Hills grassland system is degraded by chronic improper grazing, with lots of C3 exotic grasses having replaced former C4 dominants.)

Note that there are Sandhills wetlands, but they are very small; some should be included within Biophysical Setting (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 Nebraska model for it or apply 1094 as more appropriate.

The drier, coarser soiled prairies in central South Dakota that are sandy 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 Nebraska should be put into the adjacent grassland system.

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

The sand prairie of the Sheyenne Grasslands in southeast North Dakota should be put 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 in 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 microclimate 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 red cedar 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 red cedar, perhaps integrated 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 ~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 ecoregion is not highly populated by humans and, thus, few non-native and invasive species exist and persist (Narumalani et al. 2009). 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, personal communication).

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).

**Issues or Problems**

Very little data are available from pre-settlement 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 toward 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.

**Native Uncharacteristic Conditions**

See comments under "ID concerns."

**Comments**

This model for MZ31 was adapted from the model from the Rapid Assessment (RA): 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.

Add successional class to account for encroachment of Eastern red cedar and the potential for a closed-canopy juniper woodland state. This process is briefly described under the adjacency or identification concerns section but is not accounted for as a potential successional class. An example of a late development class consisting of closed-canopy juniper woodland is described in BpS 11320-31. Note that fire typically does not bring this state back to Class A (Arterburn et al. in preparation).

Succession Classes

**Mapping Rules**

Succession class letters A-E are described in the Succession Class Description section. Some classes use a leafform distinction where a qualifier is added to the class letter: Brdl (broadleaf), Con (conifer), or Mix (mixed conifer and broadleaf). UN refers to uncharacteristic native or a combination of height and cover that would not be expected under the reference condition. NP refers to not possible or a combination of height and cover which is not physiologically possible for the species in the BpS.

**Description**

Class A 2 Early Development 1 - Open

*Indicator Species*

*Description*

This class represents a mix of bare sand, including blowouts and sand draws, and extensive areas of sparse vegetative cover. At one time, 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 stabilize sand and begin movement to class Mid Development 1 -- Open. Wind was therefore modeled taking it to Mid Development 1 -- Open.

*Maximum Tree Size Class*  
None

Class B 77 Mid Development 1 - Open

*Indicator Species*

*Description*

This class represents immediate to several-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 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 will not prevent this class from moving to Late Development 1 -- Closed. In the later part of this stage, there would be moderate grazing by native ungulates and insects. Juniper species are becoming increasingly abundant throughout the Sandhills. Accordingly, fire is necessary to prevent this class from moving to Late Development 1 -- Closed.

Long-term drought -- or unusual grazing pressure -- allows the possibility of regression to class Early Development 1 -- Open.

*Maximum Tree Size Class*  
None

Class C 21 Late Development 1 - Closed

*Indicator Species*

*Description*

Class C: 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 a few years, 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.

Replacement fire occurs, most of the time causing a transition to Mid Development 1 -- Open. Roots of perennial vegetation stabilize dunes despite a lack of above-ground biomass, and grasses quickly recover following fire in this system, even under severe drought conditions (Arterburn et al. in preparation; Morrison et al. 1986; Bragg 1998; Volesky and Connot 2000; Schmeisser et al. 2009). Where the successional stage includes shrubs, mixed-severity and surface fires can occur in addition to replacement fires. With a fire-sensitive species like Eastern red cedar, both surface and mixed-severity fires can cause a shift to the mid-successional stage, depending on patterns of variability in fire severity (Twidwell et al. 2009, 2013). For this class to move back to Early Development 1 -- Open, fire must be followed by a prolonged mega-drought (Arterburn et al. in preparation).

Grazing occurs and causes a transition back to Mid Development 1 -- Open.

*Maximum Tree Size Class*  
None

Model Parameters

Deterministic Transitions

Probabilistic Transitions

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