Samuel R. McKelvie National Forest

Ecological Assessment of Sandy Lowland Sites
April 18, 2008

Prepared by

Patrick E. Reece
Prairie & Montane Enterprises LLC
PatReece@PrairieME.com
308-641-0167

Timothy L. Griffin
Rangeland Management Specialist
Nebraska National Forest
Bessey Ranger District
tgriffin@fs.fed.usa
308-533-2257 Ext. 8106

Introduction

Natural Resources Conservation Service (NRCS) soils maps were used to delineate sandy lowland sites based on the occurrence of Ipage fine sand and Ipage loamy fine sand soil series. Sandy lowland ecological sites are bordered by sands and sandy sites where depth to the water table increases and by subirrigated sites where the water table is closer to the surface. A number of sites with these soils were excluded from this resource assessment because rises in the water table had resulted in the development of subirrigated plant communities. Additionally, sites mapped as either of the indicator soils were also excluded when wind erosion had removed the top soil.

This document summarizes the average ecological condition of sandy lowlands for each allotment based on field assessments of all such sites on the Samuel R. McKelvie National Forest during August 13-24, 2007. These assessments were conducted by Pat Reece, Tim Griffin, and Buster Hand. Vegetation on most sandy lowlands is composed of a mosaic of different seral plant communities. The occurrence of only one seral stage over an entire sandy lowland is rare. Consequently, field assessments included estimating the percentage of the total area of each site occupied by different seral communities.

There are 5,083 acres of sandy lowland on the forest (Table 1), 10% in high seral, 45% in high-intermediate seral, 35% in low-intermediate seral, and 10% in low seral plant communities (Figure 1). These lowlands range in size from less than 1 acre to more than 400 acres. Cross fences often divided large sandy lowlands into 4 units, each assessed as a separate site. About 7% of the sandy lowlands within pastures were greater than 60 acres (Figure 2). About 27% of the lowlands were less than 5 acres. With the exception of the River and Snake Creek Allotments, sandy lowlands did not occur in the northern tier of grazing allotments or the Snake

Table 1. The acreage of all seral stages in the state-and-transition model for sandy lowland sites in grazing allotments at the Samuel R. McKelvie National Forest in 2007.

Allotment	Total Acreage	High Seral			High Interm.		Low Interm.			Low Seral	
		A	B	Sub	A	B	Normal	Sub A	Sub B	A	B
Powderhorn North	*996*	*3*	*6*	*21*	*391*	*226*	*348*	*0*	*0*	*1*	*0*
Powderhorn South	*347*	*48*	*35*	*13*	*52*	*174*	*16*	*0*	*7*	*3*	*0*
Diamond Bar	861	0	1	2	116	166	367	6	22	176	4
Eagle Point/Lone Tree	543	53	15	28	180	29	226	4	1	7	0
Steer Creek	474	0	0	30	155	60	159	0	0	70	0
Jennett	435	41	117	51	79	16	71	0	0	59	0
Cormorant	390	3	6	0	85	139	65	0	74	18	0
Mallard	260	0	0	0	1	0	166	0	0	93	0
Sand Lake	222	0	0	0	48	26	108	0	0	39	0
Ranger Station	213	0	0	0	28	119	28	0	38	0	0
South Falls	176	0	0	0	60	64	38	0	0	13	1
Antelope	121	0	0	0	1	53	51	0	0	7	9
River	45	5	4	5	9	5	8	1	1	8	0
Total Acreage	5083	153	183	150	1205	1077	1651	10	143	495	15

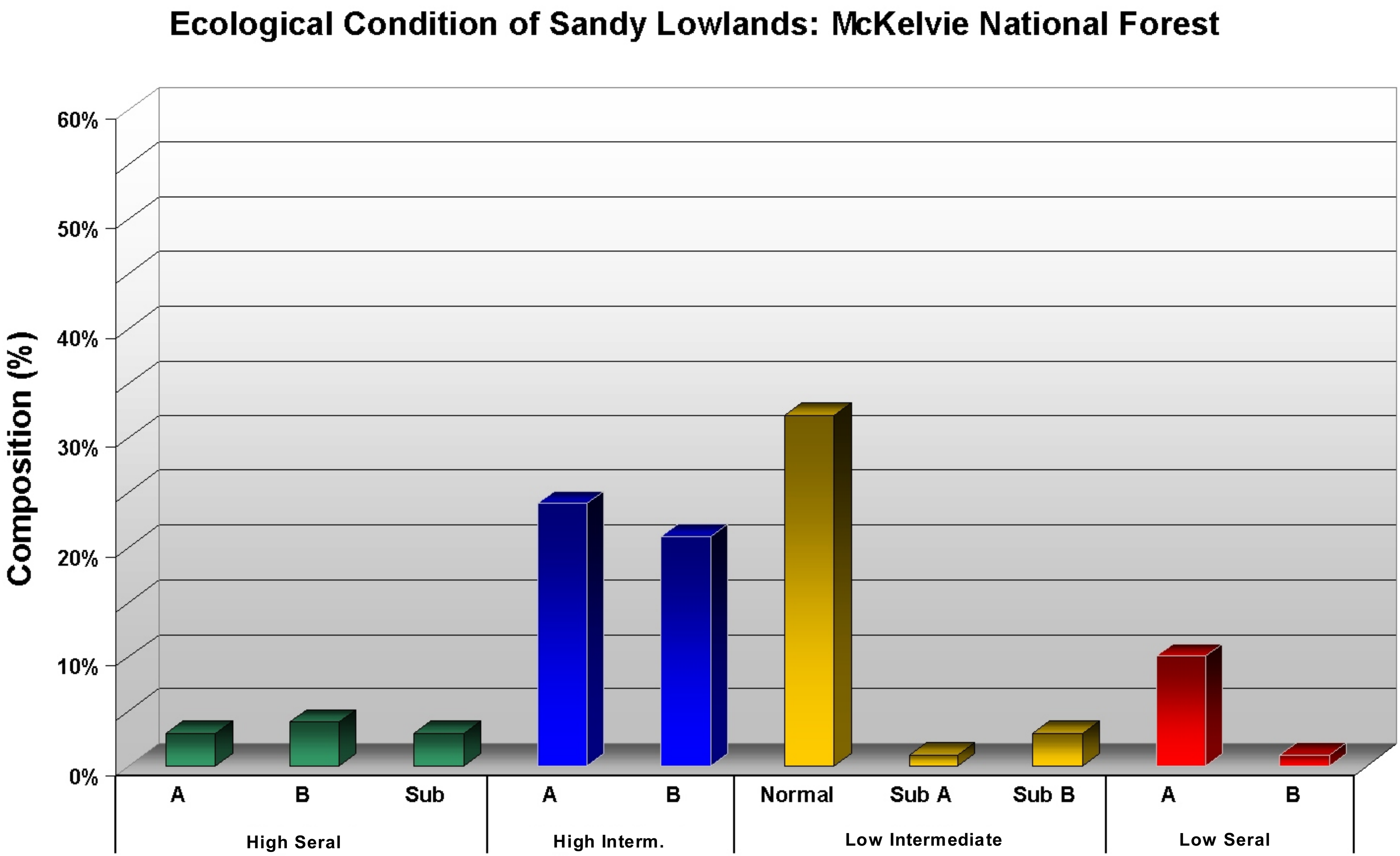


Figure 1. Overall percentage composition of seral stages on sandy lowland sites at the Samuel R. McKelvie National Forest in 2007.

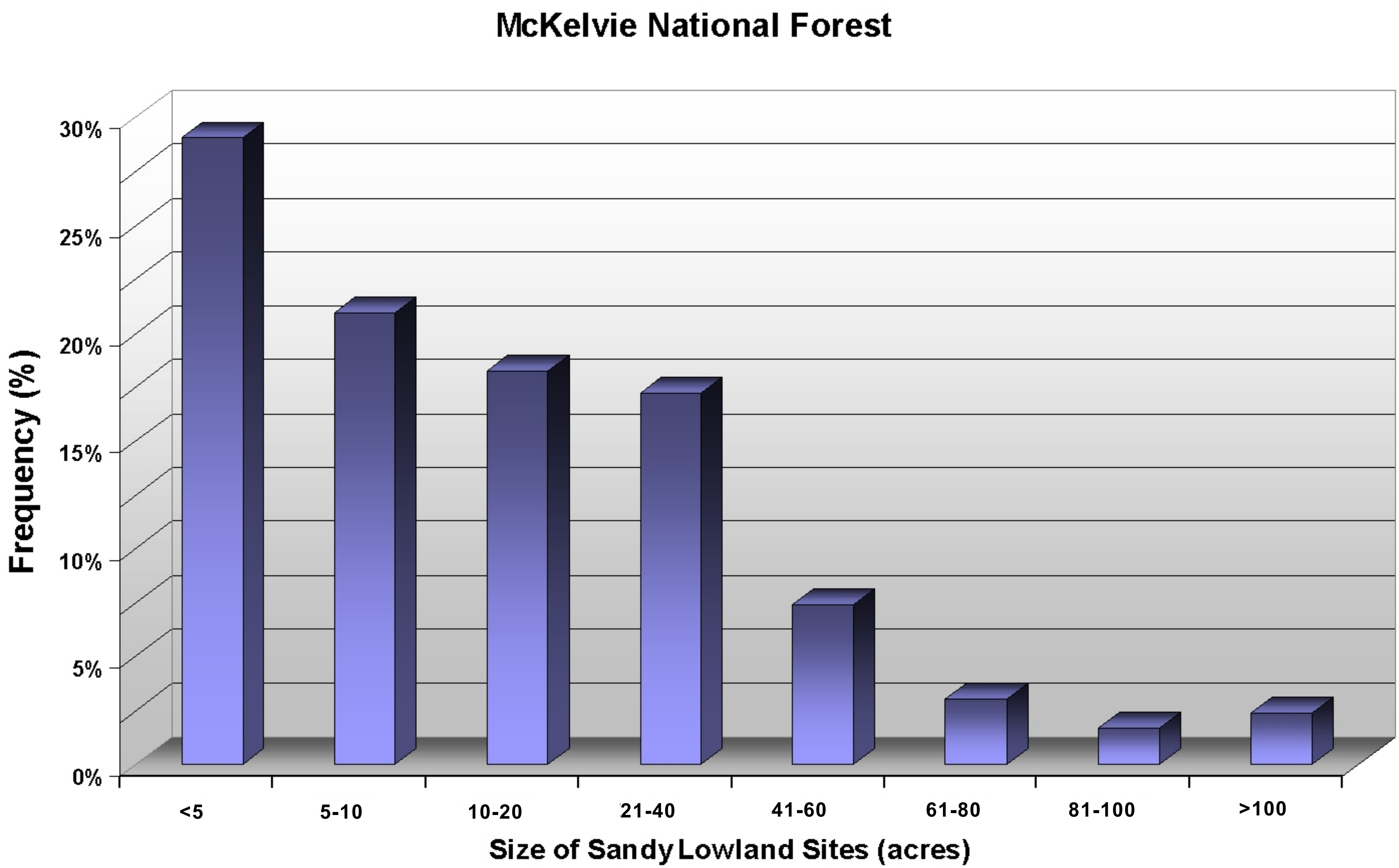


Figure 2. Frequency distribution for the land area of individual sandy lowland sites within pastures on the Samuel R. McKelvie National Forest.

Allotment in the southeast corner of the forest.

These interdunal sites and nearby locations are preferred nesting areas for greater prairie chickens (*Tympanuchus cupido*). Quality of nesting and brood-rearing cover is dependent on the height and density of standing herbage. The quality of brood-rearing cover is also dependent on the abundance of native perennial forbs. The potential for these sites to provide high quality habitat for prairie chickens and the associated suite of grassland bird species is directly related to ecological condition. The potential of these sites to produce cover increases as the composition of warm-season tallgrasses increases, which is highest for high-seral and high intermediate plant communities. The amount and distribution of high quality nesting cover during March and April will depend on the stocking rate and time of grazing in the preceding year.

Grazing systems on allotments with sandy lowlands include season-long continuous grazing, 2, 3, 4, and 5-pasture deferred-rotation and 16-pasture intensive-rotational systems. Each allotment was ranked based on the sum of the percentage of all sandy lowland acres in high seral plus high intermediate plant communities (Table 2). Ecological scores for allotments ranged from 1 to 93. The overall average ecological score for the Samuel R. McKelvie National Forest was 55. Ecological scores were below the forest average on 5 allotments, Steer Creek, Antelope, Sand Lake, Diamond Bar, and Mallard. Turnout dates, grazing systems, and pasture-use sequences during 2005-2007 are summarized in Table 3.

State-and-Transition Model

Date-of-grazing effects on forb species and warm-season tallgrasses are the primary driving variables in the ecological condition of plant communities on sandy lowland (SL) sites on the Samuel R. McKelvie National Forest. The state-and-transition model for seral stages (Figure 3) was drafted during the first 2 days of field work with assistance from Gerry Steinauer,

Table 2. Acreage and ecological condition of sandy lowlands, and ecological scores for grazing allotments at the Samuel R. McKelvie National Forest in 2007.

Allotment	Total Acreage	Number of Sites	High Seral	High Interm.	Ecological Score[1] (High & High Interm.)	Low Interm.	Low Seral
Powderhorn South	*347*	*28*	28%	65%	93	6%	1%
Jennett	435	31	48%	22%	70	16%	14%
South Falls	176	20	0%	70%	70	22%	8%
Ranger Station	213	14	0%	69%	69	31%	0%
Powerhorn North	*996*	*37*	3%	62%	65	35%	0%
River	45	3	30%	32%	62	20%	18%
Cormorant	390	22	2%	57%	60	36%	5%
Eagle Point/Lone Tree	543	25	18%	39%	56	43%	1%
Steer Creek	474	11	6%	45%	52	34%	15%
Antelope	121	6	0%	45%	45	42%	13%
Sand Lake	222	15	0%	33%	33	49%	18%
Diamond Bar	861	43	0%	33%	33	46%	21%
Mallard	260	17	0%	0%	1	64%	36%

[1]The ecological score is the sum of the percentage of all sandy lowland acres within each allotment in high seral plus high intermediate stages.

Table 3. Summary of grazing management practices for allotments in the Samuel R. McKelvie National Forest that contain sandy lowland sites. Information was from the 2005, 2006, and 2007 Annual Operating Agreements/Instructions.

Allotment[1]	Grazing Season			Summer Stocking Rate (AUM/ac)				Grazing System
	Start	End	Days	May	Jun	Jul	Seasonal	
Powderhorn-South	5/16	10/20	157		0.27-0.33		0.31-0.34	5-pasture, deferred rotation
								(1 pasture full growing-season deferment)
Jennett	6/15	10/17	123		0.23-0.31		0.31-0.33	4-pasture, deferred rotation
South Falls	5/15	11/20	189		0.11-0.18	0.22	0.36-0.68	16-pasture rotational, twice over
						0.36		
Ranger Station	6/1	9/3	121		0.19-0.26		0.27	3-pasture, deferred rotation
Powderhorn-North	5/16	10/25	162		0.35-0.42		0.36	4-pasture, deferred rotation
								(1 pasture full growing-season determent)
River	5/21	9/19	121		0.25-0.33		0.27-0.32	2-pasture, deferred rotation
	6/2	9/28	127					2-pasture, deferred rotation
								(pastures grazed only once each year)
Cormorant	6/1	10/10	131		0.32-0.33		0.32	4-pasture, deferred rotation
Eagle Point-Lone Tree	6/15	10/22	159		0.29-0.34		0.31	3-pasture, deferred rotation
	6/15	10/22	159		0.33-0.40		0.36	2-pasture, deferred rotation
								(1st pasture used twice in 2-pasture system)
Steer Creek	6/1	10/25	146		0.31		0.31	4-pasture, deferred rotation (primary)
	6/1	10/25	146		0.31-0.33		0.31-0.33	3-pasture, deferred rotation
Antelope	5/28	8/25	97		0.08-0.37		0.21-0.37	2-pasture, deferred rotation
	6/15	10/31	152					(1st pasture grazed twice 2005, 0.08-0.31 2006)
Sand Lake	6/1	10/25	146		0.12-0.42		0.36	3-pasture, deferred rotation
	5/20	10/19	152					(1st pasture grazed twice, every pasture grazed in Jun or Jul)
Diamond Bar	5/21	10/15	157	0.07	0.33-0.40		0.32-0.34	2-pasture, deferred rotation
	5/26	10/25	152	0.12				2-pasture, deferred rotation
	6/1	10/15	136				0.34	(1) season-long continuous
								(1st pasture grazed twice in both 2-pasture system)
Mallard	6/1	9/30	121		0.29		0.29	(1) season-long continuous

[1]Allotments are ranked from high to low based on the percentage of sandy lowland acreage in high seral plus high intermediate seral stages (Figure 1, Table 2).

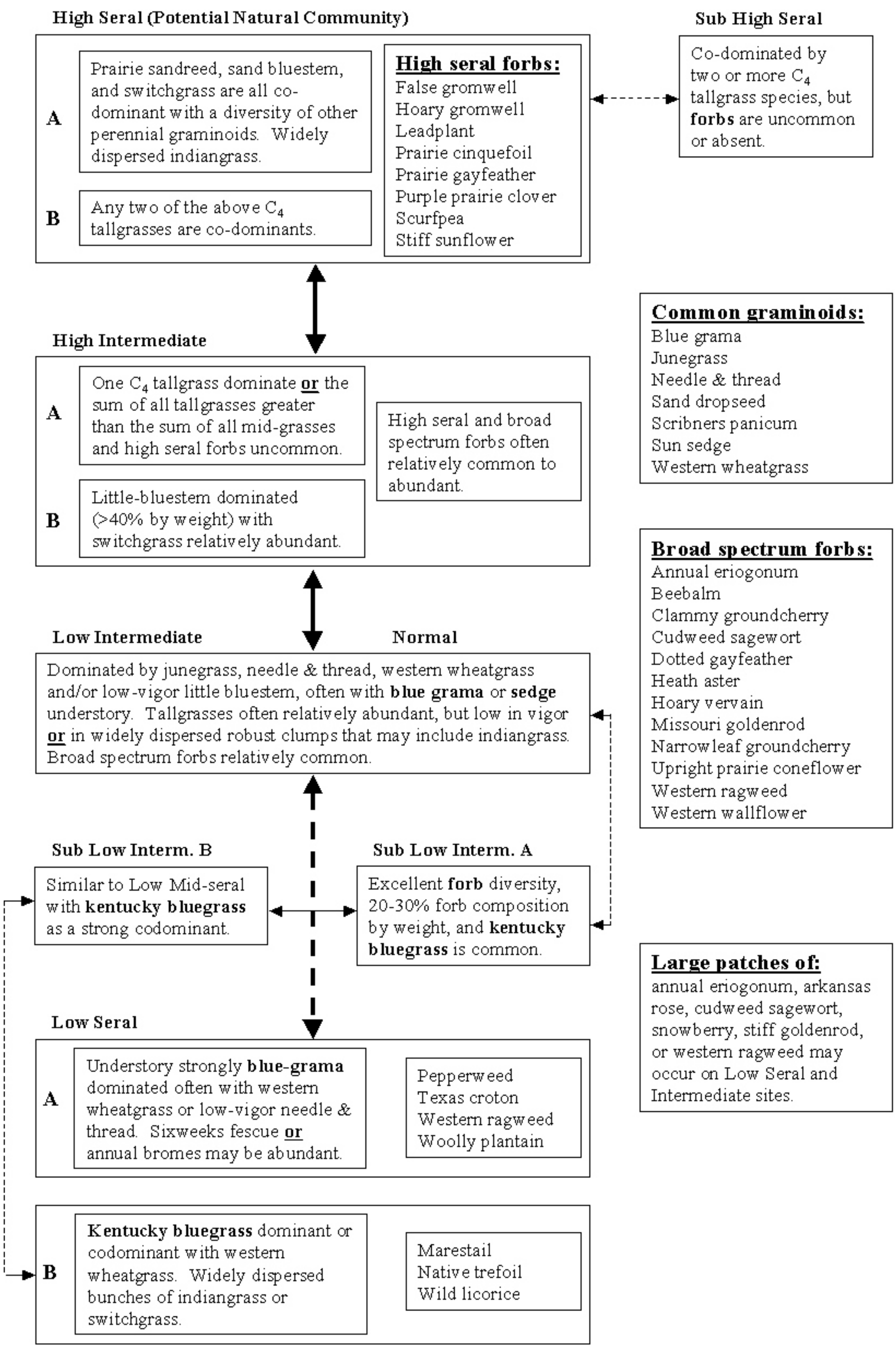


Figure 3. State-and-transition model for sandy lowland sites, 17-22" precipitation zone, at the Samuel R. McKelvie National Forest. Dotted lines are ecological thresholds.

Nebraska Game and Parks Commission. The relative abundance, vigor, and species composition of tallgrasses and forbs were used to separate seral stages.

Nomenclature in the state-and-transition model follows Dan Uresk's work. Synonymous names for seral stages used in the Land Resource Management Plan (LRMP) for the McKelvie Geographic Area are presented in Table 4. The current percentage of sandy lowland acres in high (late) seral, 10%, is well below the target level of 30 to 50% (Table 4). Additionally, the current percentage of sandy lowland in low (early) intermediate seral plant communities, 35%, exceeds the LRMP target range of 1 to 20%. It will be necessary to move relatively large percentages of high (late) and low (early) intermediate communities up to high (late) seral stages in order to accomplish the LRMP.

Table 4. Land Resource Management Plan (LRMP) synonyms and target levels of ecological condition for seral categories used in this document.

LRMP Synonym	Target Levels (%)	2007 Status (%)	Within This Document
Late Seral	30-50	10	High Seral
Late Intermediate	30-50	45	High Intermediate
Early Intermediate	1-20	35	Low Intermediate
Early Seral	1-20	10	Low Seral

Transitions among seral stages are likely to be measurably more rapid the closer communities are to high seral stages. About 87% of the total sandy lowland area on the forest is in low intermediate or higher stages that are likely to respond to grazing management designed to enhance warm-season tallgrasses. Grazing management that enhances tallgrass vigor and composition generally enhances high seral forb populations. Recovery of high seral forbs in low seral and low-intermediate plant communities will be dependent on the occurrence of remnants.

Low Seral

Tallgrass species generally are absent or they occur only in widely dispersed clumps in low seral communities. Given the limited amount of grass seedling establishment on native grasslands, transition from low seral to intermediate seral stages will require growth of tallgrass rhizomes into the area from adjacent plant communities in higher seral stages. The time line for this transition will be relatively long compared to transitions among other seral stages where tallgrasses are relatively abundant. The likelihood of tallgrasses returning to low-seral areas increases as the width of these communities declines and the frequency of full growing-season deferment increases within that pasture. Conversely, low-seral areas are less likely to overcome the **threshold of no tallgrasses** as the distance to livestock water declines. Additionally, there were plant communities where kentucky bluegrass was dominant or common in low seral stages (Low Seral B) and in low intermediate stages (Sub Low Intermediate A and B). These bluegrass communities composed less than 4% of all communities on sandy lowland sites. They appeared to occur on low areas within the sandy lowlands where subirrigated or overflow site conditions were likely to occur. Transition of bluegrass communities to higher seral stages may require a change in soil hydrological conditions.

Dominant forb species are distinctly different in low seral communities compared to higher seral stages. Low seral A communities were characterized by annual species, such as pepperweed, texas croton, and woolly plantain. Low seral B communities were characterized by an abundance of wild licorice, native trefoil, and marestail. Additionally, large patches of western ragweed, annual eriogonum, arkansas rose, cudweed sagewort, stiff goldenrod, or western snowberry occurred in low-seral and intermediate-seral plant communities. Broad spectrum forb species occurred in plant communities in all seral stages. These species included annual eriogonum, beebalm, clammy groundcherry, cudweed sagewort, dotted gayfeather, heath aster, hoary vervain, missouri goldenrod, narrowleaf groundcherry, upright prairie coneflower, western ragweed, and western wallflower.

Low and High Intermediate Seral

Low intermediate communities were dominated by cool-season grasses (junegrass, needle-and-thread, or western wheatgrass) or low vigor little bluestem with an understory of blue grama or sedges. Dan Uresk's undated USFS document for seral stages in dry valleys of the Sandhills, classified communities with high cover x frequency index values for sedges as low intermediate which is consistent with our state-and-transition model. Warm-season (C_4) tallgrasses were relatively abundant, but low in vigor in low intermediate plant communities. In contrast, the vigor and percentage of total herbage produced by tallgrasses were measurably higher in high intermediate-seral A communities compared to normal low seral plant communities.

High intermediate A communities were often mosaics created by changes in the dominance of C_4 tallgrasses among prairie sandreed, sand bluestem, or switchgrass. On a relatively small percentage of SL sites (<2%), a collective dominance of all tallgrass species combined compared to all mid-grasses combined was used to classify communities as high intermediate seral A. High intermediate B communities were dominated by vigorous populations of little bluestem with a high relative abundance of switchgrass. Dan Uresk classified communities with high cover x frequency indices for little bluestem as high intermediate, which is consistent with our state-and-transition model.

High Seral

About 10% of all the sandy lowland area on the forest was co-dominated by 2 or more C_4

tallgrass species and classified as high seral. These communities appeared to have the highest potential for herbage production and visual obstruction. About 30% of the high seral sandy lowland area was classified as **sub** high seral because high seral and broad spectrum forbs were uncommon or absent. The forb component of high seral A and B communities was dominated by high seral species, false gromwell, hoary gromwell, lead plant, prairie cinquefoil, prairie gayfeather, purple prairie clover, scurfpea, or stiff sunflower. High seral forb species were also relatively common to abundant in most high intermediate A and B communities. Consequently, about 45% of all the sandy lowland area on the forest is rich in forbs.

Prairie sandreed was not used as the exclusive indicator of high seral communities, as suggested by Dan Uresk. We observed that a higher potential natural community (PNC) occurs on sandy lowland sites, which is characterized by the co-dominance of 2 or more C_4 tallgrasses and an abundance of high seral forbs. We can only speculate why forbs are uncommon or absent in **sub** high seral communities. It is possible that repeated years of excessive grazing pressure completely removed most of the perennial forbs during retrogression before tallgrasses were able to regain dominance in these areas during secondary succession. Low seral A communities were characterized by an abundance of annual forbs. It is possible that communities with a relatively high abundance of high seral forbs have not been reduced to low seral stages in the past. Populations of some high seral forbs, such as stiff sunflower, decline rapidly when grazed in June or July in consecutive years.

Grazing Management Recommendations

Ecological condition of many plant communities in intermediate seral stages can be improved within 2 to 5 years with changes in grazing management. These changes may include one or more of the following: (1) do not graze pastures during June or July in consecutive years,

(2) delay turnout until mid-June or later, (3) provide full growing season deferment to pastures at least once every 4 years, (4) incorporate periodic rest., nonuse for 12 or more months, or (5) reduce stocking rates.

Overgrazing

Cattle are selective grazers. They graze preferred plant species in preferred locations. Cattle selectively graze grasses and forbs at immature stages of development whenever possible. Grasses and sedges in vegetative stages and forbs in pre-floral bud stages are characterized by seasonally high levels of nutrient density and digestibility. Forage quality and the likelihood of overgrazing of palatable species declines as plants mature.

Daily rates of herbage production rapidly decline when plants begin to flower. The preceding stages are often referred to as rapid-growth windows. They occur when air temperature and soil water content are simultaneously favorable for different species. Overgrazing can be defined as the level and date of defoliation beyond which grazing reduces herbage production in the subsequent year. The likelihood of preferred species being overgrazed by cattle is highest during rapid growth windows because plants are highly nutritious and the suitability of air temperatures and soil water conditions tend to decline rapidly after rapid-growth windows in semi-arid ecosystems which reduces the opportunity for recovery before killing frost.

Published studies of warm-season tallgrasses (prairie sandreed and sand bluestem) and a high seral forb, stiff sunflower, at the University of Nebraska, Gudmundsen Sandhills Laboratory indicate that these species are consistently overgrazed during their rapid-growth windows in June and July. Consequently, we recommend that pastures in Sandhills ecosystems not be grazed during June or July in consecutive years. Doing so causes a measurable decline in herbage production potential of tallgrasses and relatively rapid declines in stiff sunflower populations.

Ecological Condition

Given the dominance of tallgrasses in high seral and high intermediate seral stages on sandy, sands, and choppy sands ecological sites, management recommendations for sandy lowlands will be beneficial for most of the grassland in each pasture. Ecological condition appears to be the highest ranked objective in the Land Resource Management Plan (LRMP) for the McKelvie Geographic Area. The primary driving variable controlling ecological condition in grazed ecosystems is the grazing system or time of grazing. Grazing systems are nothing more than a tentative schedule of when pastures will be grazed or nongrazed.

Grazing Systems

All pastures in allotments that contain sandy lowlands are currently grazed every year. During 2005-2007, average seasonal stocking rates in these allotments ranged from 0.21 AUM/ac to 0.68 AUM/ac. When the **grazing** season occurs primarily during the **growing** season (May-September) every year, a minimum of 3 pastures will be needed for a 1-herd, once over, 3-pasture rotation to avoid consecutive years of June or July grazing in most years. Four or more pastures will provide the opportunity to eliminate consecutive-year June or July grazing.

Periodic full-growing-season deferment from spring greenup to killing frost is very beneficial for improving or sustaining high levels of vigor in preferred plant species and concurrently high levels of ecological condition. Benefits of this practice are substantiated by published research and the notably high ecological condition of Sandhills pastures that have only been dormant-season grazed for a number of years. Conversely, the relative benefit to an allotment will decline as the frequency of full-growing-season deferment declines. When a single pasture is deferred until after killing frost, the percentage of the allotment effected declines as the number of pastures increases. It is likely that the ability to capitalize on the synergy of full-growing-season deferment over the entire allotment will become relatively small when the area of the allotment deferred until after killing frost drops below 25%. Consequently, when there are 5 or more pastures in a grazing system, it may be necessary to provide full-growing-season deferment to several pastures in some years to provide this best-case scenario treatment to pastures every 4th year or more frequently.

Delaying turnout dates until mid-June or later will increase the likelihood of avoiding consecutive-year June or July grazing and increase the opportunity for full-growing-season deferment in 1 or more pastures with rotation grazing systems. Additionally, more current-year herbage will be available to cattle when they begin grazing compared to earlier turnout dates. Increases in current-year herbage at the beginning of the "summer" grazing season generally more than offset increases in calf weights during the delay and result in a net reduction in grazing pressure through much of the grazing season. Reduced grazing pressure reduces the percentage of tallgrass tillers grazed and the percentage of defoliation of grazed tillers.

Number of Pastures

In the Sandhills, avoiding consecutive years of June or July grazing is of greater value for plant vigor than reducing the total number of days that grazing will occur in a pasture. Most of the economical and ecological benefit of increasing the number of pastures occurs with 7 or 8 pastures. Beyond that level, fencing costs are difficult to justify because the acreages from which capital improvement and maintenance costs might be recovered, become disproportionately small per unit length of fence. Grazing management on allotments with 3 or less pastures could be measurably improved by using privately owned pastures in conjunction with allotment pastures to create 1-herd rest-rotation or deferred-rotation grazing systems with 4 or more pastures.

Plant Structure

Quality prairie grouse nesting cover is generally found in areas with high to moderately productive soils that are annually grazed by livestock at light grazing intensities or in areas that have received one or more years of rest. High vegetation structure can be achieved on moderate and highly productive soils dominated by mid and/or tallgrasses (late or late intermediate seral stage composition). Moderate structure can be achieved on similar productive soils depending on grazing use levels. Grasslands dominated by shortgrass species in the early intermediate or early seral stage will not achieve moderate or higher structure regardless of grazing levels. Low vegetative structure can result from low productivity soils, a dominance of low stature plant species or from heavy utilization of mid and tallgrasses.

Target ranges of plant structure appear to be the second prioritized objective in the LRMP for the McKelvie Geographic Area. Height and density of plant cover are controlled by ecological condition and stocking rate. Because of the dominance of tallgrasses, high seral and high intermediate seral communities have the greatest potential to produce the herbage needed for structure. The ability of low intermediate and low seral communities to produce target levels of structure is limited by the dominance of mid-grasses or shortgrasses and an increasing percentage of bare ground as ecological condition declines. Within the potential of a given seral community, stocking rate is the primary driving variable for structure.

Herbage production potential of Sandhills plant communities is determined by the integration of precipitation regime and grazing-date effects during the preceding 2 years. Quality and uniformity of structure are controlled by how much residual herbage has accumulated during the previous year(s) and by how much current-year herbage is allocated for cattle in the current year.

When all pastures are grazed each year, the only reliable management option for making measurable increases in structure is the reduction of stocking rates which increases the amount of residual herbage left on the ground. It may be possible to achieve small increases in structure by delaying turnout until mid-June in allotments where cattle have historically started grazing in mid-May. It is likely that the magnitude of stocking rate reductions could be smaller through the use of rest-rotation grazing systems that rest 1 or more pastures for 12 months or longer. Frequency and duration of rest and percentage of the total allotment acreage rested will determine the effectiveness of rest-rotation grazing systems in meeting structure objectives. Resting pastures is likely to be more beneficial for lowland than upland sites because cattle preferentially graze level to gently rolling areas. Accumulation of coarse stems by tallgrasses in rested pastures will produce "wolf plants" that cattle are less likely to graze in subsequent years. This is more likely to reduce grazing on lowlands compared to using deferred-rotation systems in conjunction with reduced stocking rates because wolf plants are much less likely to develop on lowlands where cattle preferentially graze during the growing season..

Rest could be limited to pastures with sandy lowlands if consecutive-year June or July grazing can be avoided in non-rested pastures. Rotation of rest among pastures with an abundance of sandy lowland would enhance the ecological condition and structure on lowlands. The quality of habitat for prairie grouse and the associated suite of nongame grassland birds which includes a growing list of species of concern could experience measurable year-to-year changes with drought. When severe or prolonged drought reduce herbage production decisions on how to allocate that diminished supply of herbage become critical for wildlife populations and beef producers. These decisions should be predetermined and implemented on a timely basis based on a drought management plan. The reliability and time span of precipitation forecasts have substantially improved during the past 10 years. Drought models now integrate soil-water and precipitation information to forecast the likelihood of drought stress with considerable accuracy up to 3 months into the future (National Drought Mitigation Center at the University of Nebraska (www.drought.unl.edu/DM/monitor).

Future Planning

The Nebraska National Forest could collaborate with a conservation non-government organization (NGO) willing to purchase 2 allotments that could be managed for maximum ecological and wildlife habitat benefit. Some pastures in the NGO allotments could be used as grass banks to provide rest to pastures in other allotments in most years. Concurrently, a high percentage of land area in the allotment acquired by the NGO would be in high ecological condition and provide high quality habitat for prairie grouse and associated species. All pastures of the acquired allotments could be rested when prolonged drought-induced declines in herbage production warranted nongrazing. Additonally, in average or better precipitation years, prescribed burning could be conducted on the NGO allotments to determine the effectiveness of using fire to increase perennial forb diversity and density.

References

Reece, P.E., J.W. Morris, W.H. Schacht, A.E. Koehler, J.D. Volesky, and L.E. Moser. 2007. Prairie Sandreed Response to Preceding-Year Defoliation and Precipitation Regime. Great Plains Research 17:215-224.

Reece, P.E., W.H. Schacht, and J.D. Volesky. 2007. Skillful grazing management on semi-arid rangeland. Univ. of Nebraska Extension. EC162.

Reece, P.E., W.H. Schacht, A.E. Koehler. 2004. Stiff sunflower population dynamics on summer-grazed Sandhills rangeland. Rangeland Ecology and Management 57:76-82.

Reece, P.E., J.E. Brummer, B.K. Northup, A.E. Koehler, and L.E. Moser. 2004. Interactions among western ragweed and other Sandhills species after drought. Rangeland Ecology and Management 57:25-30.

Reece, P.E., J.S. Nixon, L.E. Moser, and S.S. Waller. 2002. Seasonal dynamics of prairie sandreed rhizome development. J. Range Manage. 55:182-187.

Reece, P.E., J.D. Volesky, and Walter H. Schacht. 2001. Integrating management objectives and grazing strategies on semi-arid rangeland. Univ. of Nebraska Cooperative Extension. EC01-158.

Reece, P.E., J.D. Volesky, and W.H. Schacht. 2001. Cover for wildlife after summer grazing on Sandhills rangeland. J. Range Manage. 54:126-131.

Cullan, A.P., P.E. Reece, and W.H. Schacht. 1999. Early-summer grazing effects on defoliation and tiller demography of prairie sandreed. J. Range Manage. 52:447-453.

Reece, P.E., J.E. Brummer, R.K. Engel, B.K. Northup, and J.T. Nichols. 1996. Total organic reserves in prairie sandreed and sand bluestem after four years of grazing treatments. J. Range Manage. 49:112-116.

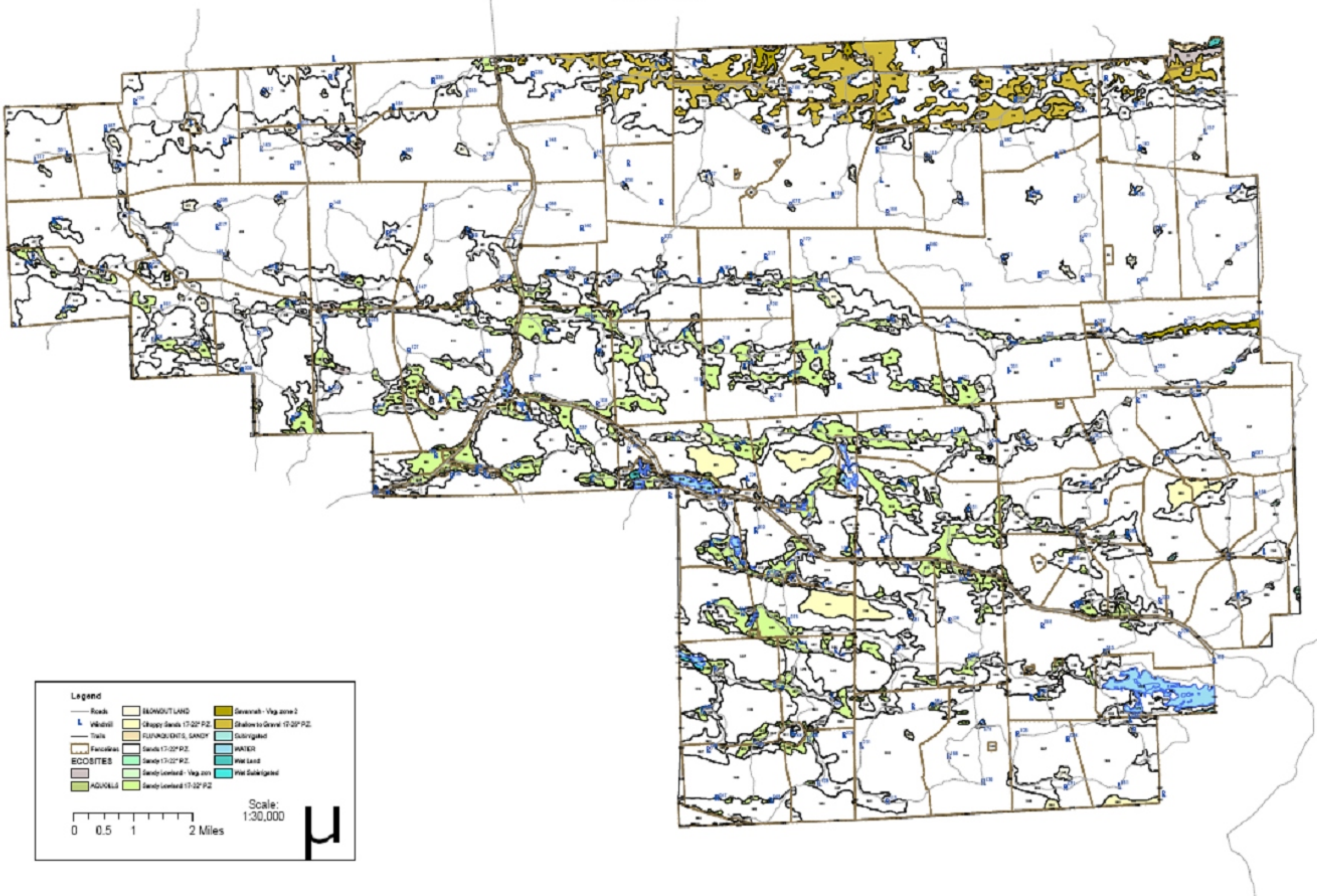
Reece, P.E., J.D. Alexander, and J.R. Johnson. 1991. Drought management on range and pastureland: A handbook for Nebraska and South Dakota. EC91-123. 23 p. Univ. NE, Lincoln.

Waller, S.S., L.E. Moser, and P.E. Reece. 1985. Understanding grass growth: The key to profitable livestock production. Trabon Printing Co., Inc. Kansas City, Missouri. 20 p.

Appendix I

Map of sandy lowland sites on the Samuel R. McKelvie National Forest, based on the occurrence of the Ipage soil series. Digitized data resides at the Bessey Ranger District.

Samuel R. McKelvie NF
Ecosites



Appendix II

Table 2. Acreage and ecological condition of sandy lowlands, and ecological scores for grazing allotments at the Samuel R. McKelvie National Forest in 2007.

Figure 3. State-and-transition model for sandy lowland sites, 17-22" precipitation zone, at the Samuel R. McKelvie National Forest.

Graphic Summaries of the Overall Ecological Condition of Sandy Lowlands (SL) within each Allotment in the Order of Their Ecological Score.

Ecological Score = Percentage in High Seral + Percentage in High Intermediate Seral

Powderhorn South
Jennett
South Falls
Ranger Station
Powderhorn North
River
Cormorant
Eagle Point/Lone Tree
Steer Creek
Antelope
Sand Lake
Diamond Bar
Mallard

Table 2. Acreage and ecological condition of sandy lowlands, and ecological scores for grazing allotments at the Samuel R. McKelvie National Forest in 2007.

Allotment	Total Acreage	Number of Sites	High Seral	High Interm.	Ecological Score[1] (High & High Interm.)	Low Interm.	Low Seral
Powderhorn South	*347*	*28*	28%	65%	93	6%	1%
Jennett	435	31	48%	22%	70	16%	14%
South Falls	176	20	0%	70%	70	22%	8%
Ranger Station	213	14	0%	69%	69	31%	0%
Powerhorn North	*996*	*37*	3%	62%	65	35%	0%
River	45	3	30%	32%	62	20%	18%
Cormorant	390	22	2%	57%	60	36%	5%
Eagle Point/Lone Tree	543	25	18%	39%	56	43%	1%
Steer Creek	474	11	6%	45%	52	34%	15%
Antelope	121	6	0%	45%	45	42%	13%
Sand Lake	222	15	0%	33%	33	49%	18%
Diamond Bar	861	43	0%	33%	33	46%	21%
Mallard	260	17	0%	0%	1	64%	36%

[1]The ecological score is the sum of the percentage of all sandy lowland acres within each allotment in high seral plus high intermediate stages.

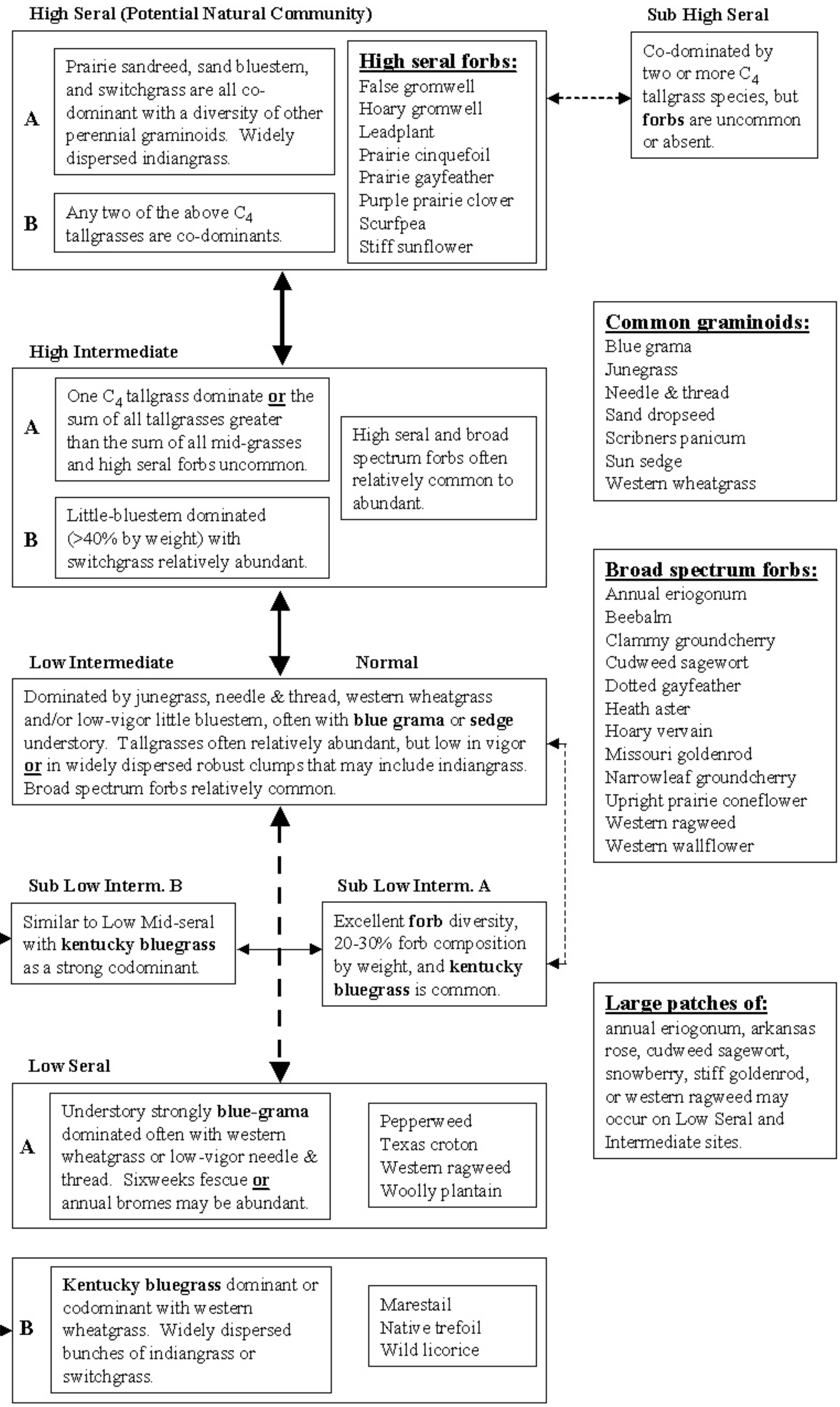
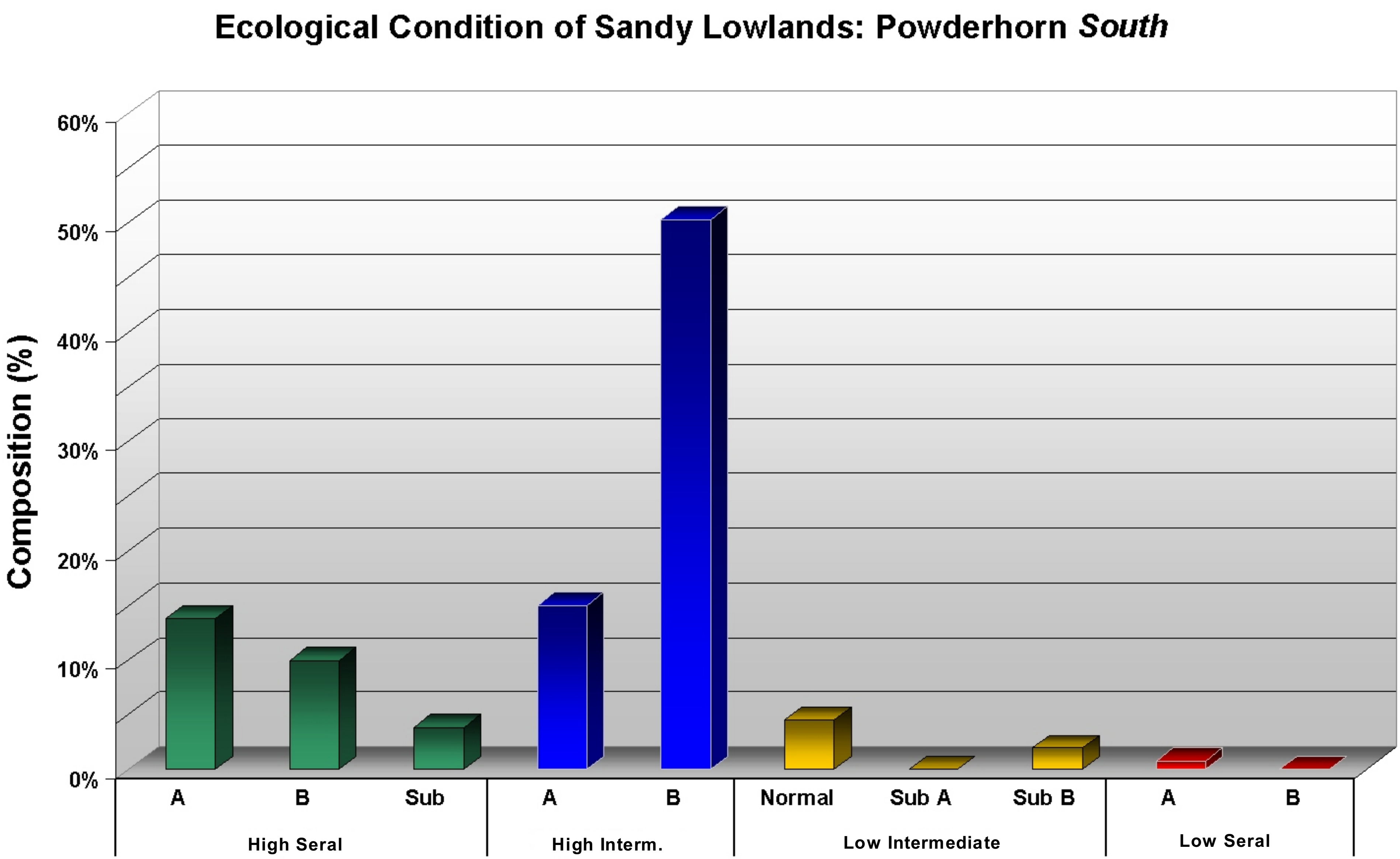
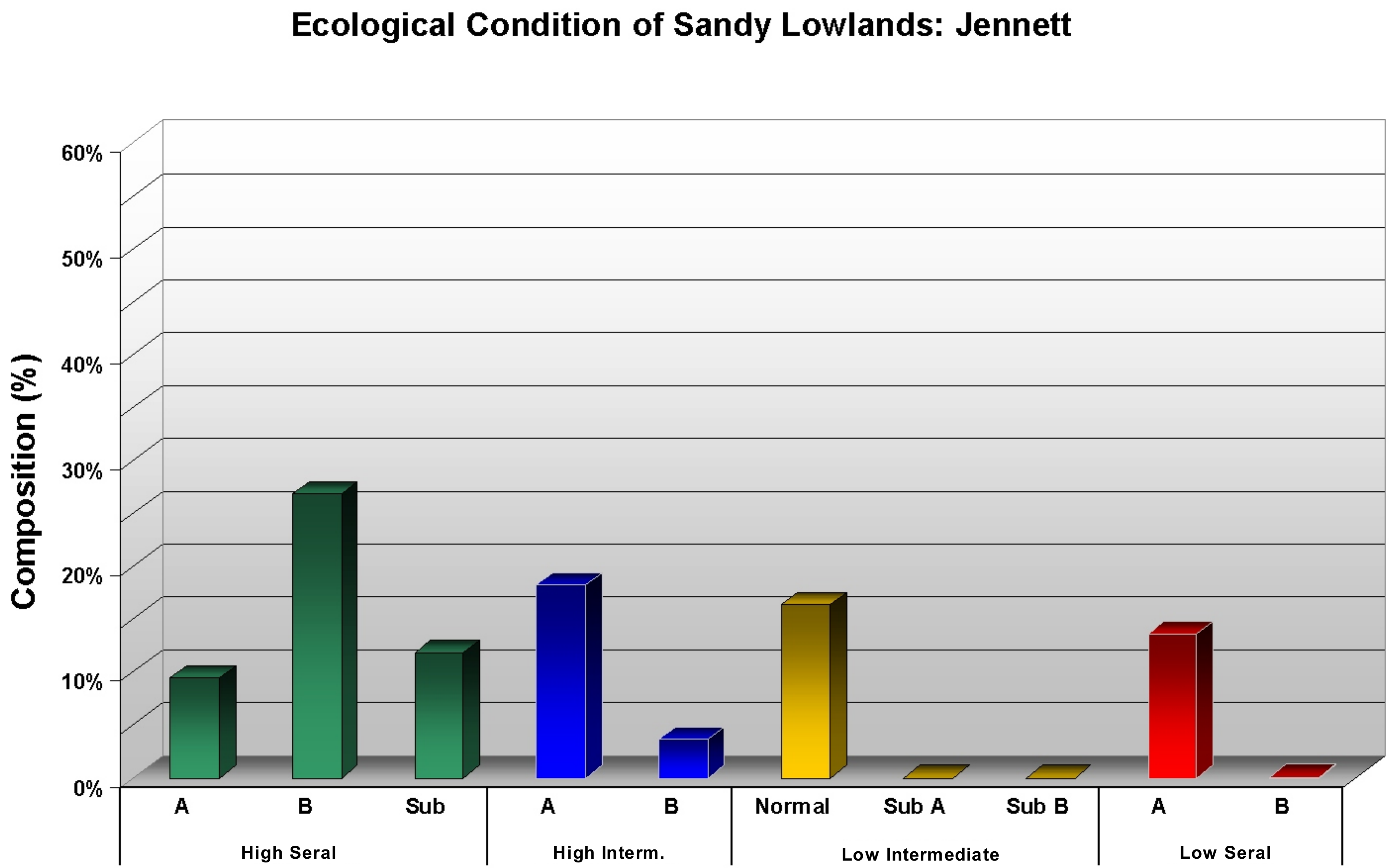
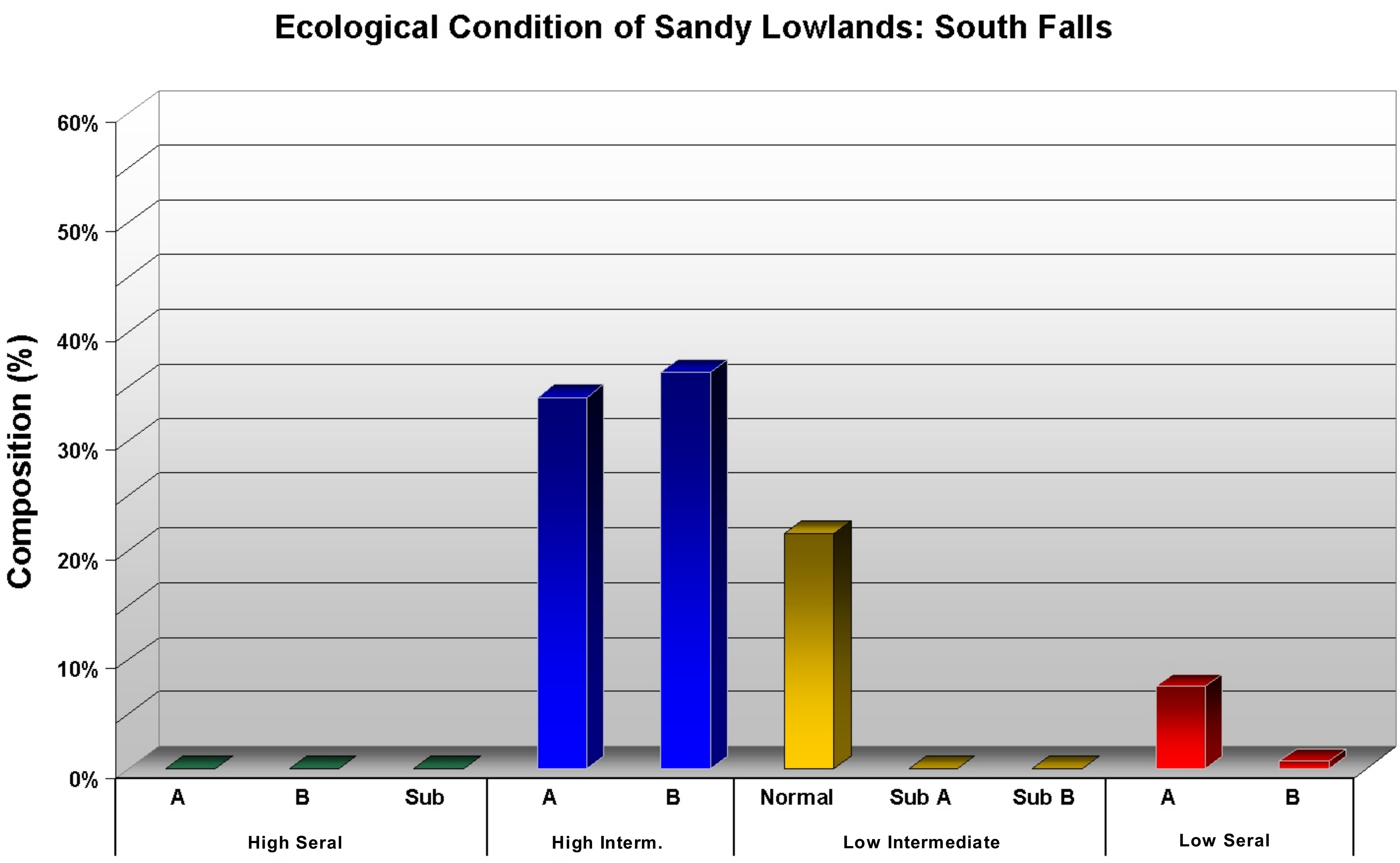
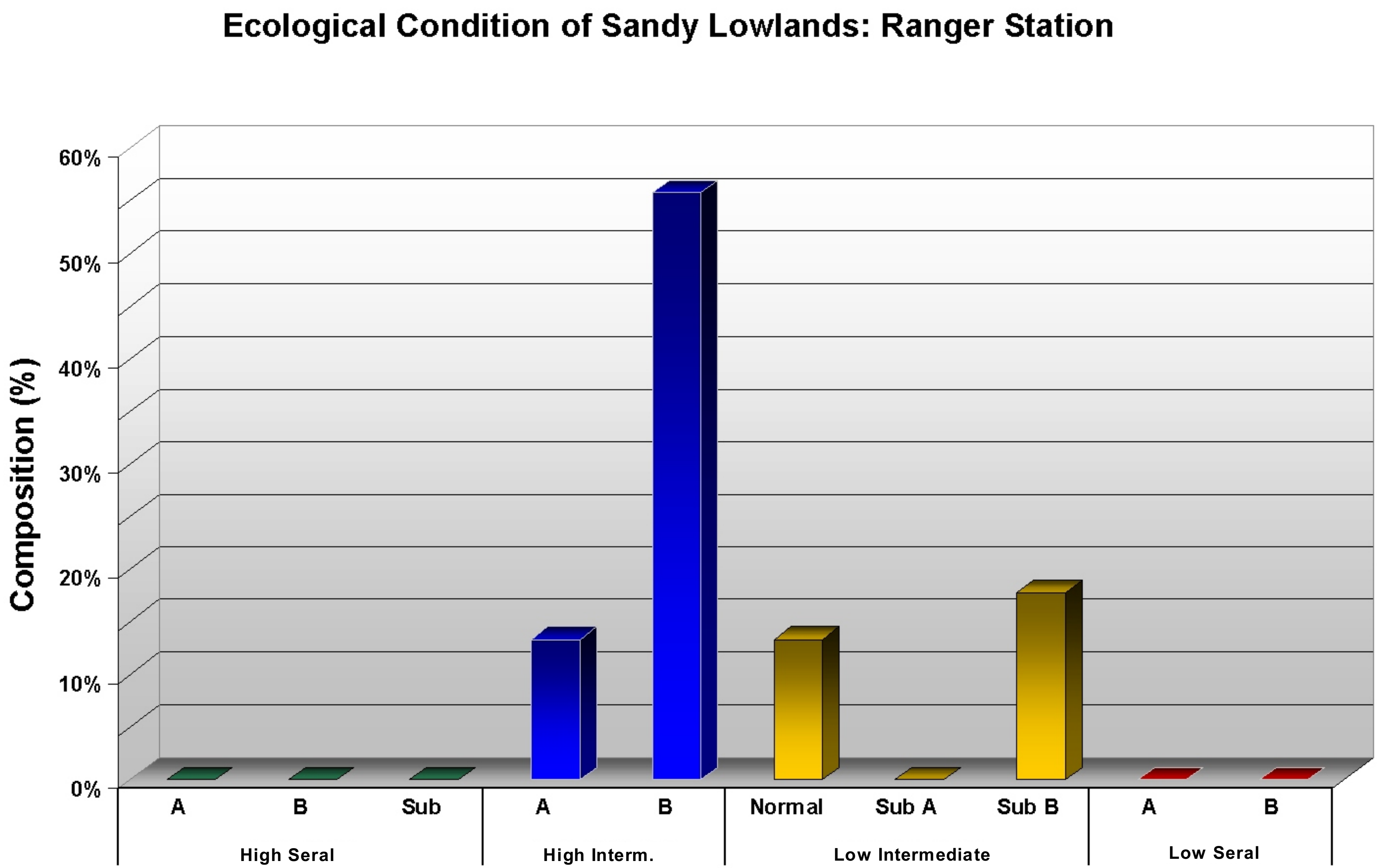


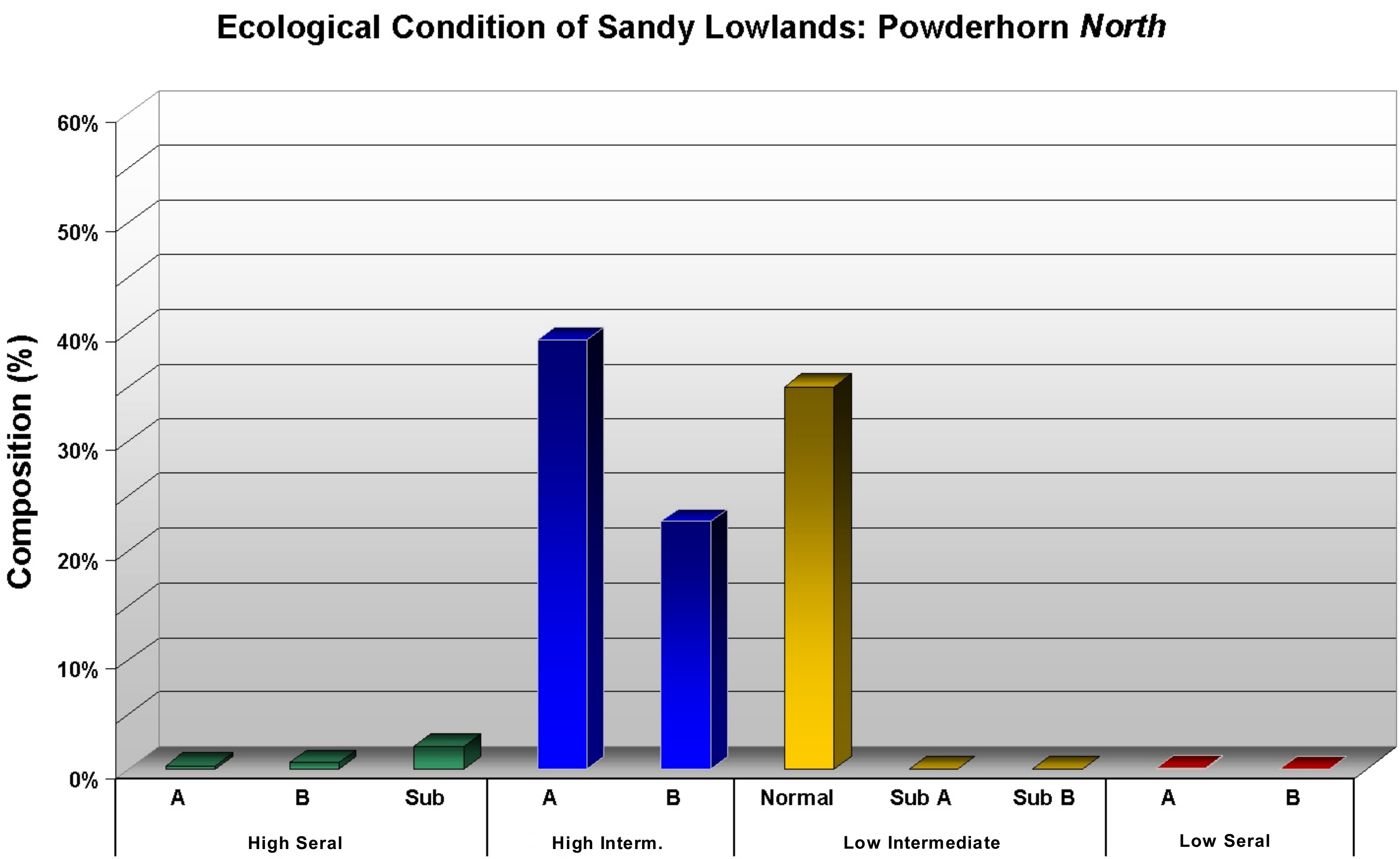
Figure 3. State-and-transition model for sandy lowland sites, 17-22” precipitation zone, at the Samuel R. McKelvie National Forest. Dotted lines are ecological thresholds.


Ecological Condition of Sandy Lowlands: Powderhorn *South*
Composition (%)
60%
50%
40%
30%
20%
10%
0%
A
B
Sub
A
B
Normal
Sub A
Sub B
A
B
High Seral
High Interm.
Low Intermediate
Low Seral

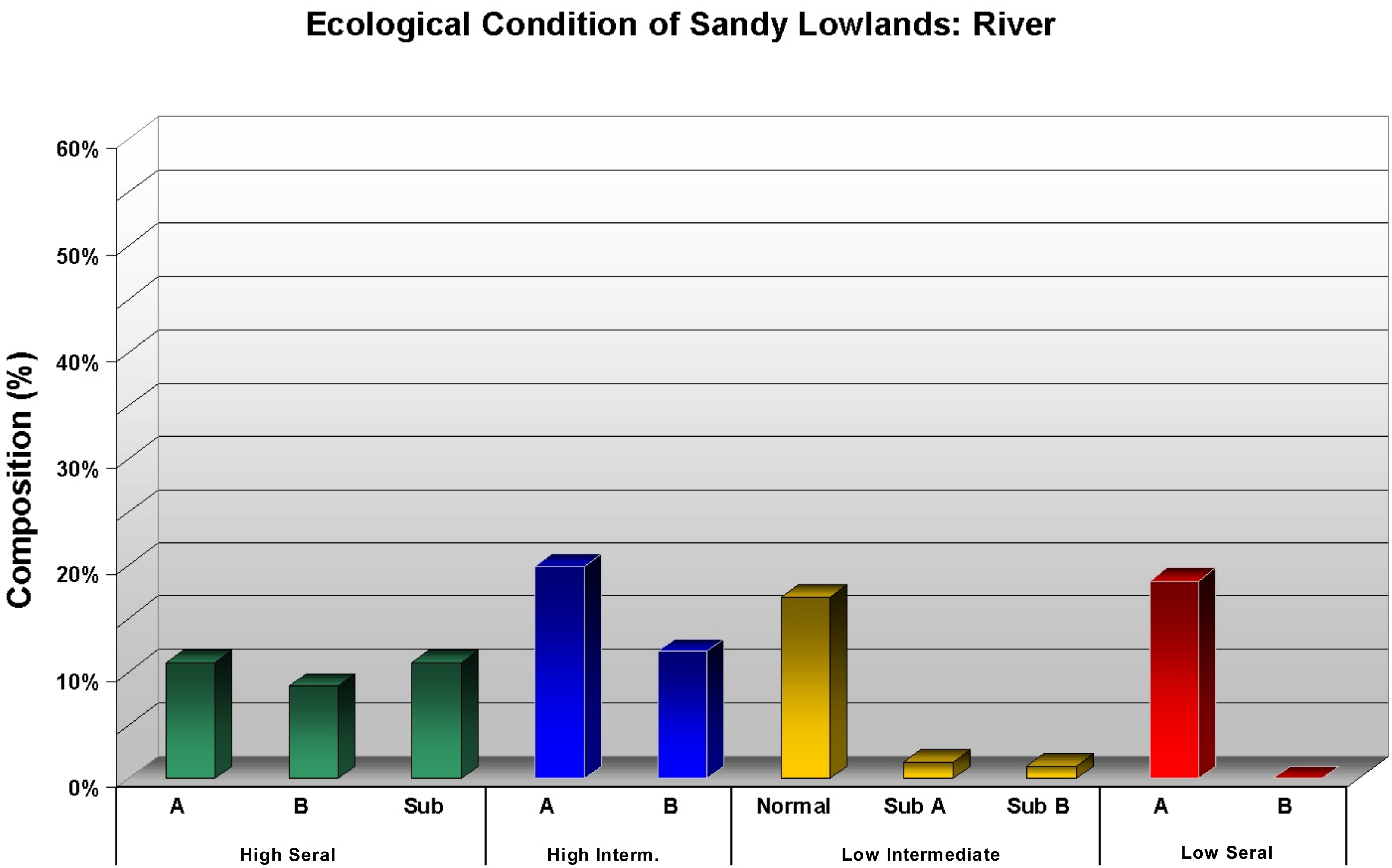

Ecological Condition of Sandy Lowlands: Jennett
Composition (%)
60%
50%
40%
30%
20%
10%
0%
A
B
Sub
A
B
Normal
Sub A
Sub B
A
B
High Seral
High Interm.
Low Intermediate
Low Seral

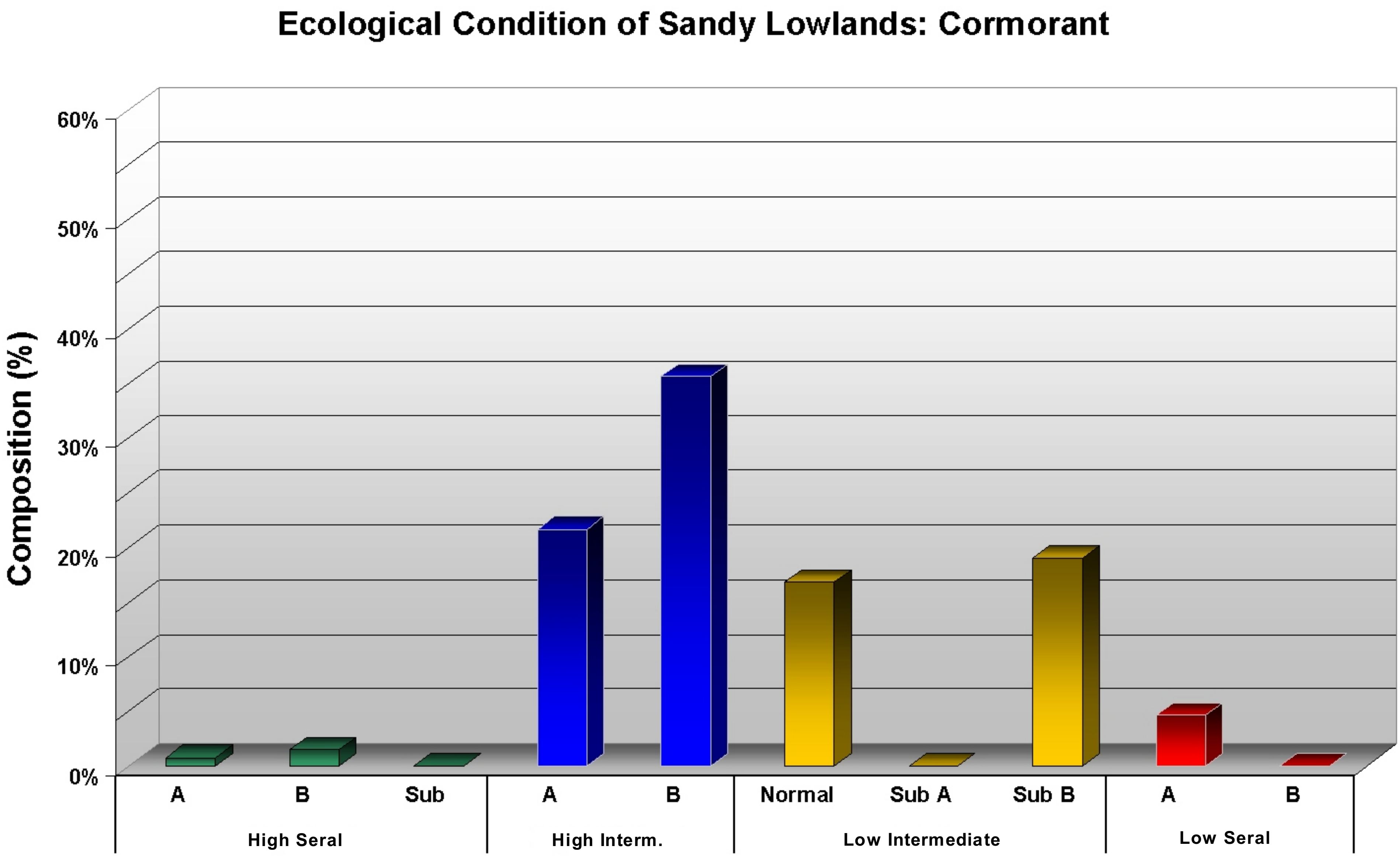

Ecological Condition of Sandy Lowlands: South Falls
Composition (%)
60%
50%
40%
30%
20%
10%
0%
A
B
Sub
A
B
Normal
Sub A
Sub B
A
B
High Seral
High Interm.
Low Intermediate
Low Seral

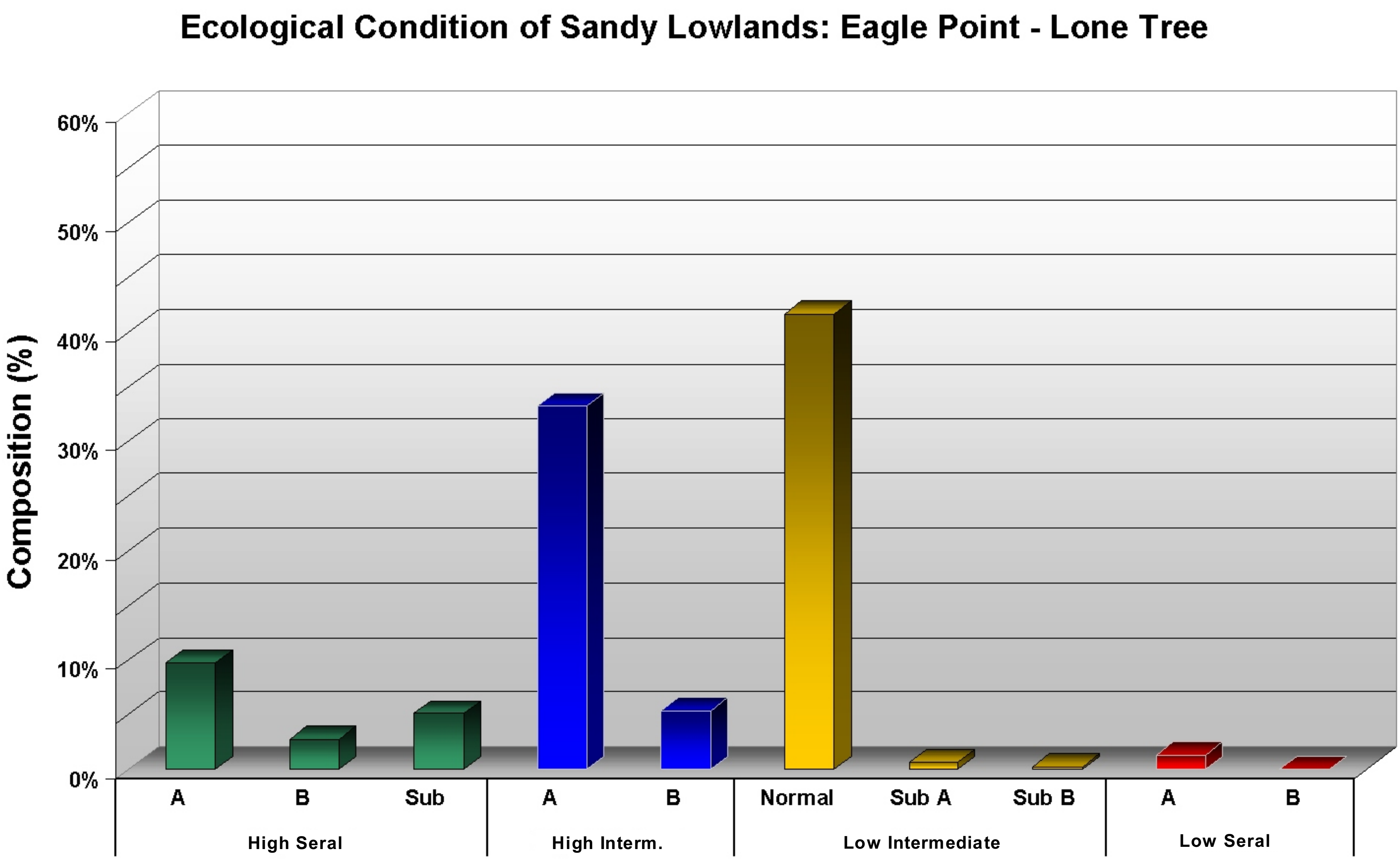

Ecological Condition of Sandy Lowlands: Ranger Station
Composition (%)
60%
50%
40%
30%
20%
10%
0%
A
B
Sub
A
B
Normal
Sub A
Sub B
A
B
High Seral
High Interm.
Low Intermediate
Low Seral

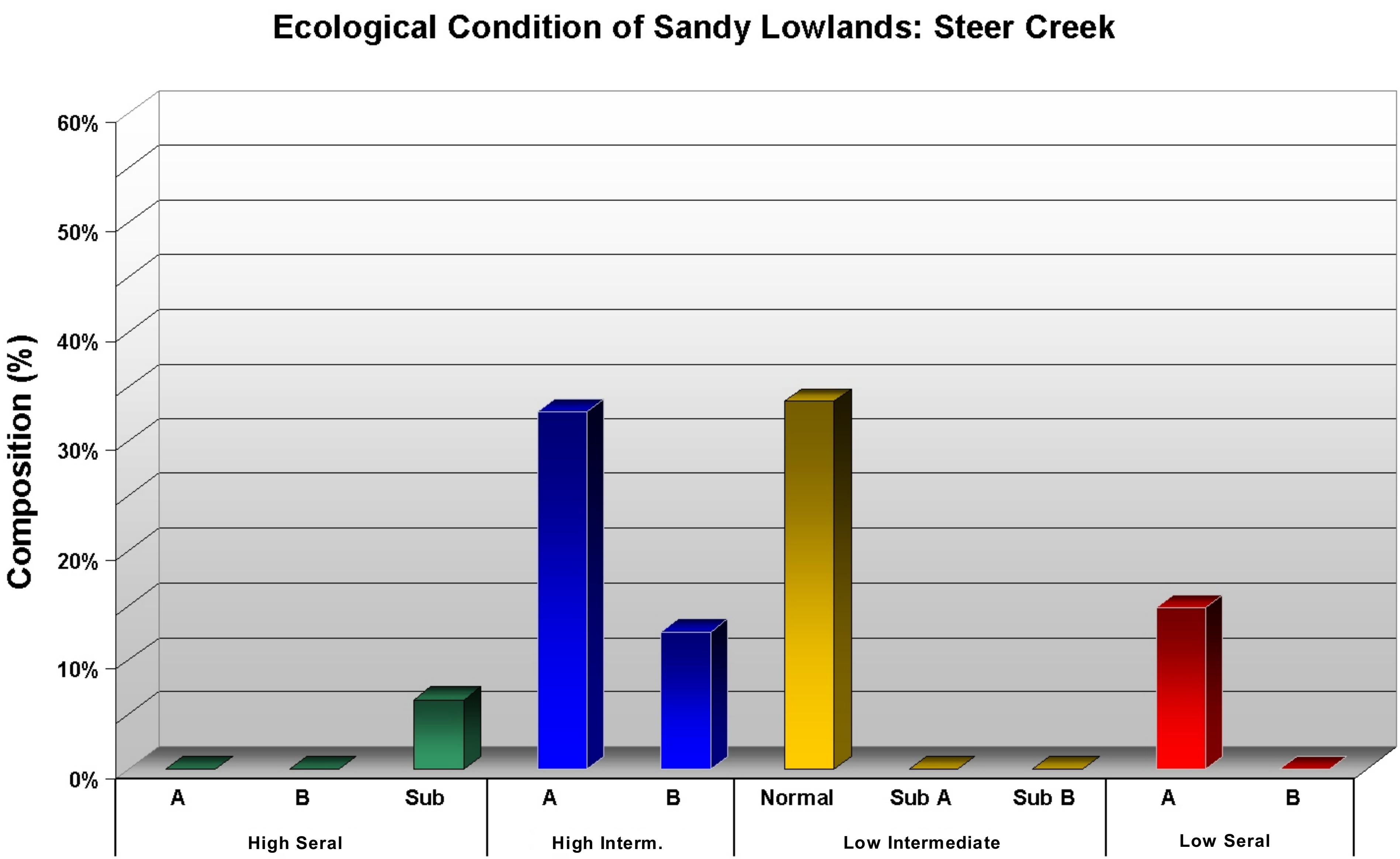


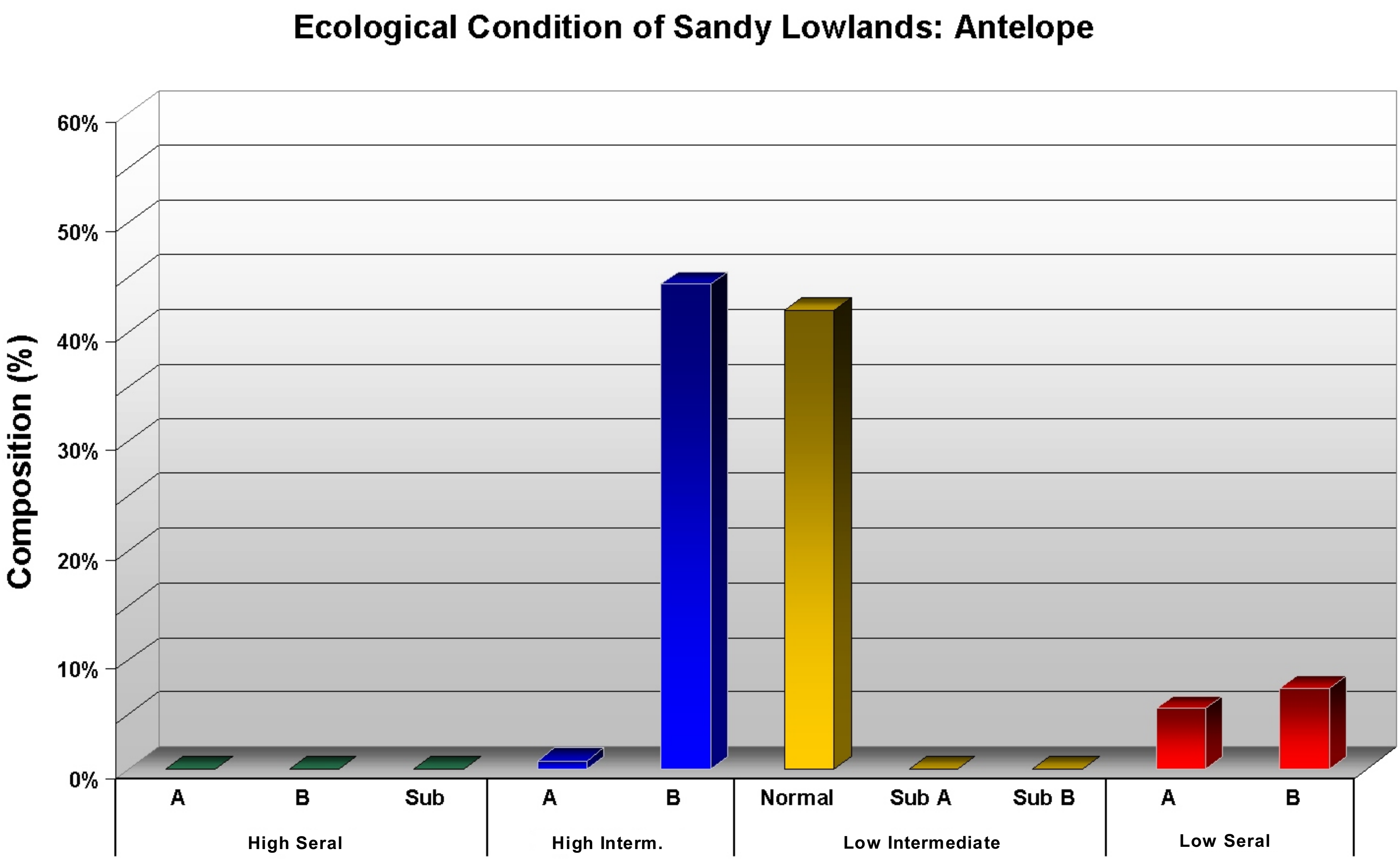
Ecological Condition of Sandy Lowlands: Powderhorn *North*
Composition (%)
60%
50%
40%
30%
20%
10%
0%
A
B
Sub
A
B
Normal
Sub A
Sub B
A
B
High Seral
High Interm.
Low Intermediate
Low Seral

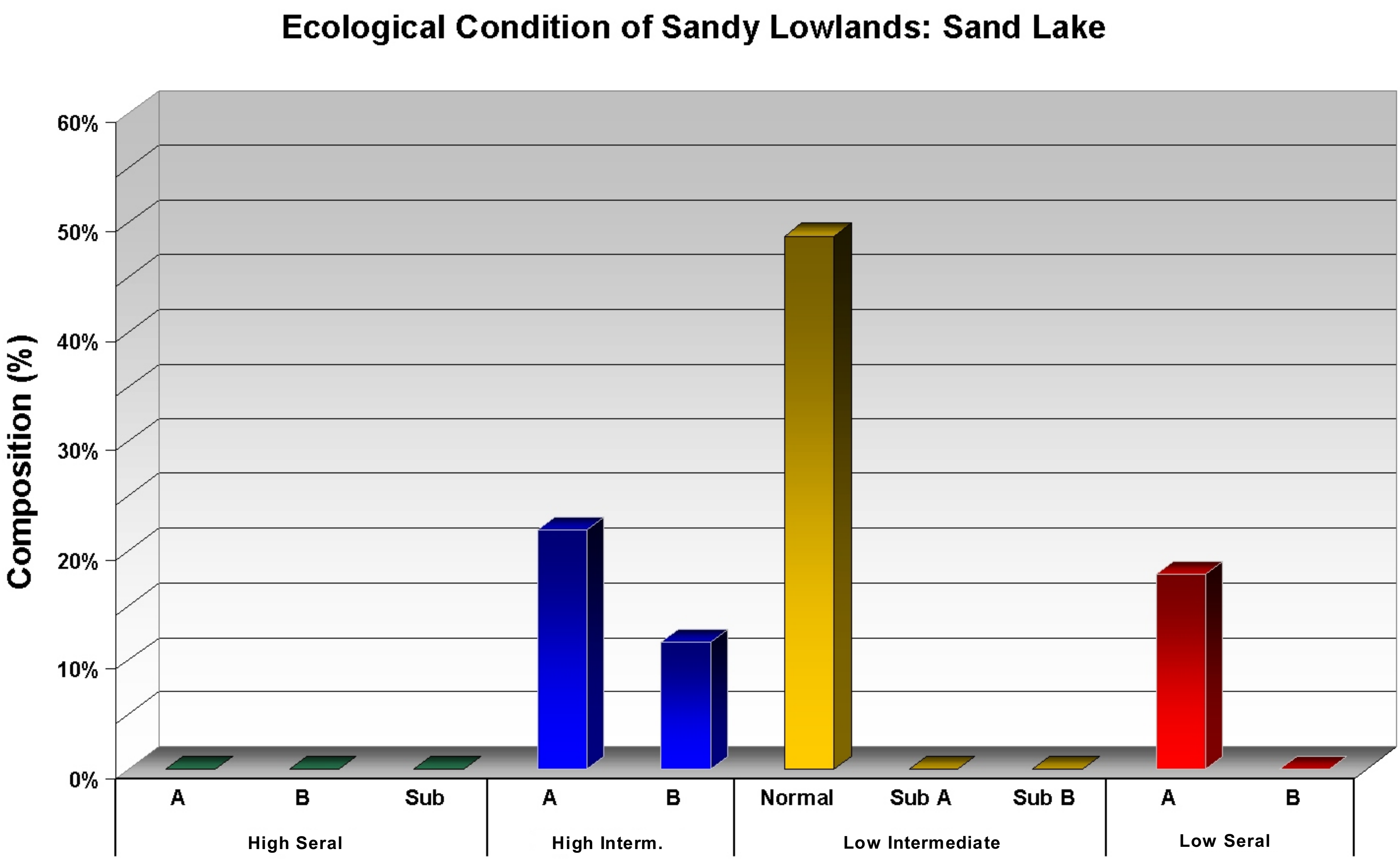

Ecological Condition of Sandy Lowlands: River
Composition (%)
60%
50%
40%
30%
20%
10%
0%
A
B
Sub
A
B
Normal
Sub A
Sub B
A
B
High Seral
High Interm.
Low Intermediate
Low Seral

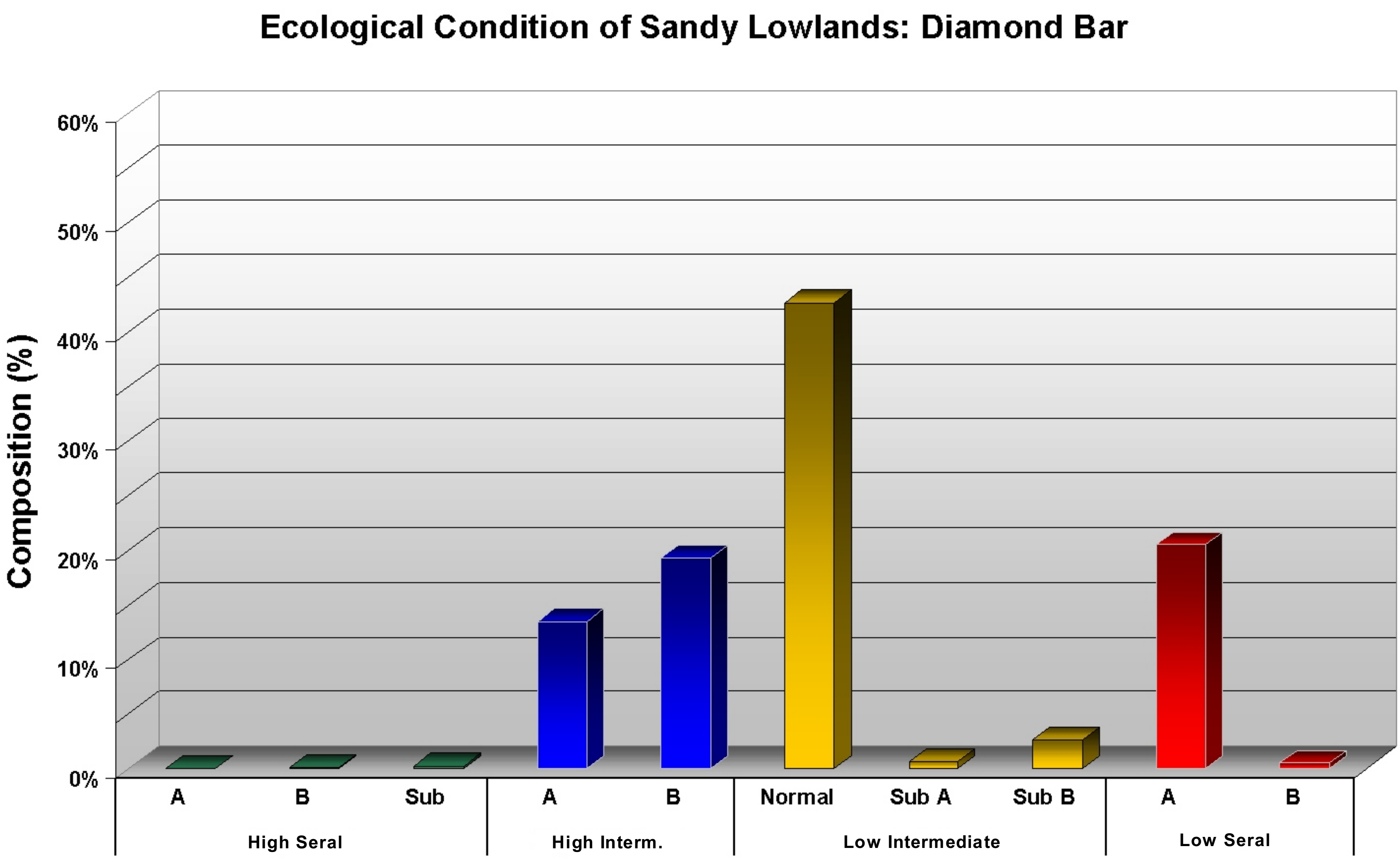

Ecological Condition of Sandy Lowlands: Cormorant
Composition (%)
60%
50%
40%
30%
20%
10%
0%
A
B
Sub
A
B
Normal
Sub A
Sub B
A
B
High Seral
High Interm.
Low Intermediate
Low Seral

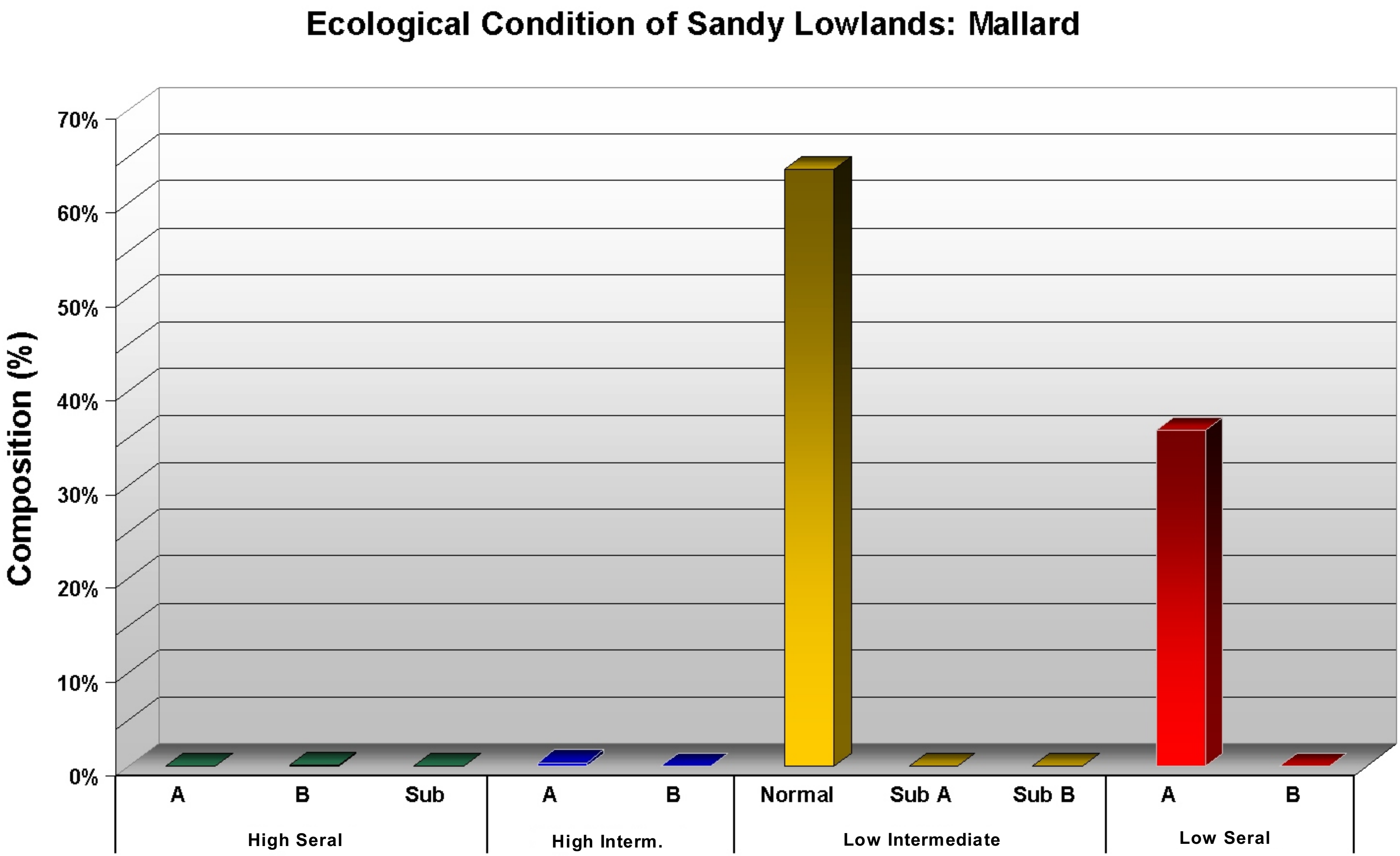

Ecological Condition of Sandy Lowlands: Eagle Point - Lone Tree
Composition (%)
60%
50%
40%
30%
20%
10%
0%
A
B
Sub
A
B
Normal
Sub A
Sub B
A
B
High Seral
High Interm.
Low Intermediate
Low Seral


Ecological Condition of Sandy Lowlands: Steer Creek
Composition (%)
60%
50%
40%
30%
20%
10%
0%
A
B
Sub
A
B
Normal
Sub A
Sub B
A
B
High Seral
High Interm.
Low Intermediate
Low Seral


Ecological Condition of Sandy Lowlands: Antelope
Composition (%)
60%
50%
40%
30%
20%
10%
0%
A
B
Sub
A
B
Normal
Sub A
Sub B
A
B
High Seral
High Interm.
Low Intermediate
Low Seral


Ecological Condition of Sandy Lowlands: Sand Lake
Composition (%)
60%
50%
40%
30%
20%
10%
0%
A
B
Sub
A
B
Normal
Sub A
Sub B
A
B
High Seral
High Interm.
Low Intermediate
Low Seral


Ecological Condition of Sandy Lowlands: Diamond Bar
Composition (%)
60%
50%
40%
30%
20%
10%
0%
A
B
Sub
A
B
Normal
Sub A
Sub B
A
B
High Seral
High Interm.
Low Intermediate
Low Seral


Ecological Condition of Sandy Lowlands: Mallard
Composition (%)
70%
60%
50%
40%
30%
20%
10%
0%
A
B
Sub
A
B
Normal
Sub A
Sub B
A
B
High Seral
High Interm.
Low Intermediate
Low Seral

Appendix III

Common Names and Scientific Epitaphs for Plant Species
Listed in the State-and-Transition Model for Sandy Lowlands

Graminoids
Forbs
Shrubs

Great Plains Flora Association. 1986. Flora of the Great Plains. University Press of Kansas, Lawrence, Kansas.

Graminoids

Annual bromes	*Bromus tectorum* L. *Bromus japonicus* Thunb. ex Murr.
Blue grama	*Bouteloua gracilis* (H.B.K.) Lag. ex Griffiths
Indiangrass	*Sorghastrum nutans* (L.) Nash
Junegrass	*Koelaria pyramidata* (Lam.) Beauv.
Kentucky bluegrass	*Poa pratensis* L.
Little bluestem	*Andropogon scoparius* Michx. [*Schizachyrium scoparium* (Michx.) Nash-Gould]
Needle and thread	*Stipa comata* Trin. & Rupr.
Prairie sandreed	*Calamovilfa longifolia* (Hook.) Scribn.
Sand bluestem	*Andropogon hallii* (Hack.)
Sand dropseed	*Sporobolus crytandrus* (Torr.) A. Gray
Scribner panicum	*Dichanthelium oligosanthes* (Schult.) Gould var. *scribnerianum* (Nash) Gould
Sedges	*Carex* L. spp.
Sixweeks fescue	*Vulpia octoflora* Walt.
Sun sedge	*Carex heliophila* Mack.
Switchgrass	*Panicum virgatum* L.
Western wheatgrass	*Agropyron smithii* Rydb.

Forbs

Annual eriogonum	*Eriogonum annuum* Nutt.
Beebalm	*Monarda* L. spp.
Clammy groundcherry	*Physalis heterophylla* Nees
Cudweed sagewort	*Artemesia ludoviciana* Nutt.
Dotted gayfeather	*Liatrus punctata* Hook.
False gromwell	*Onosmodium molle* (Michx.) var. *occidentale* (Mack.) I.M. Johnst.
Heath aster	*Aster ericoides* L.
Hoary gromwell	*Lithospermum canescens* (Michx.) Lehm.
Hoary vervain	*Verbena stricta* Vent.
Marestail	*Conyza canadensis* (L.) Cronq.
Missouri goldenrod	*Solidago missouriensis* Nutt.
Narrowleaf groundcherry	*Physalis virginiana* Miller
Native trefoil	*Lotus pushianus* Clem. & Clem.
Pepperweed	*Lepidium densiflorum* Schrad.
Prairie cinquefoil	*Potential pensylvanica* L.
Prairie gayfeather	*Liatris squarrosa* (L.) Michx.
Purple prairieclover	*Dalea purpurea* Vent.
Scurfpea	*Psoralea* L. spp.
Stiff goldenrod	*Salidaga ridgida* L.
Stiff sunflower	*Helianthus rigida* (Cass.) Desf.
Texas Croton	*Croton texensis* (Kl.) Muell. Arg.
Upright prairie coneflower	*Ratibida columnifera* (Nutt.) Woot. & Standl.
Western ragweed	*Ambrosia psilostachya* DC.
Western wallflower	*Erysimum capitatum* (Doulg.) Greene
Wild licorice	*Glycyrrhiza lepidota* Pursh.
Woolly plantain	*Plantago patagonica* Jacq.

Shrubs

Arkansas rose	*Rosa arkansana* Porter
Leadplant	*Amorpha canescens* Pursh.
Western snowberry	*Symphoricarpos occidentalis* Hook.

Appendix IV

Selected photographs of seral plant communities on sandy lowlands on the Samuel R. McKelvie National Forest during August, 2007.

1. Mosaic with High Intermediate A and B and Low Intermediate in the foreground and High Seral A and B in the distant background.

2. High Seral A.

3. High Seral A and B with an abundance of High Seral forbs.

4. High Intermediate A with prairie sandreed dominance.

5. High Intermediate B with hoary gromwell.

6. Low Intermediate with cool-season grass dominance.

7. Low Seral A with blue grama dominance and abundant annual forbs and grasses.