Enkhjargal Darambazar, **Timothy DelCurto**[1], **Daalkhaijav Damiran**, and **Abe A. Clark**,

Eastern Oregon Agricultural Research Center, Union, Oregon 97883

Robert V. Taylor, The Nature Conservancy, Enterprise, OR 97828.

Species Composition and Diversity on Northwestern Bunchgrass Prairie Rangelands

Running footer: species composition and diversity on bunchgrass prairie

1 table.

[1]Correspondence: Timothy DelCurto, Eastern Oregon Agricultural Research Center, P.O. Box E, Union, Oregon 97883.

Suggested Citation for Paper:

Darambazar, E., T. DelCurto, D. Damiran, A. A. Clark, and R. V. Taylor. 2007. Species composition and diversity on northwestern bunchgrass prairie rangelands. *In:* Proceedings of Western Section, American Society of Animal Sciences 58:233-236.

Proceedings, Western Section, American Society of Animal Science

Vol. 58, 2007

SPECIES COMPOSITION AND DIVERSITY ON NORTHWESTERN BUNCHGRASS PRAIRIE RANGELANDS[1]

E. Darambazar[2], T. DelCurto[2], D. Damiran[2], A. A. Clark[2], and R. V. Taylor[3]

[2]Eastern Oregon Agricultural Research Center, OSU, Union 97883

[3]The Nature Conservancy, Enterprise, OR 97828

ABSTRACT: Management and conservation of rangelands are increasingly concerned with maintaining productivity, species composition, and diversity of native plant communities. We estimated aboveground annual productivity, species composition, and diversity of a native bunchgrass type community across 1152, 0.5 m^2 plots at The Nature Conservancy's Zumwalt Prairie Preserve in northeastern Oregon. Standing crop was estimated by clipping current year's crop to ground level and canopy cover was estimated visually as cover classes. The Shannon diversity index (*H*) was used to characterize species diversity in the study area. Across the study sites 186 plant species were observed, approximately 80% of which were native perennial species. Native bunchgrasses and perennials contributed nearly 80% to the total standing crop with 16% attributed to invading and/or introduced species. We found that the prairie was low in productivity but high in evenness of species abundance.

[1] The project was supported by the National Research Initiative of the USDA Cooperative State Research, Education and Extension Service, grant number 2006-35101-16572, The Nature Conservancy and Oregon State University's Eastern Oregon Agricultural Research Center. We thank Uranbileg Daalkhaijav, Samuel Wyffels, and Amartuvshin Daalkhaijav for assistance with field work; also our thanks to Phil Shephard for logistical support.

Key Words: Aboveground Biomass, Species Richness, Bunchgrass Community

Introduction

It is important to monitor the status of native bunchgrass prairie vegetation because of their high value for wildlife and the maintenance of the existing grassland remnants. In the Pacific Northwest, there has been concern that grazing of late-successional ecosystems may decrease plant species diversity on a local and regional scale and adversely affect rare, threatened, or endangered species. Collins (1992) found community aboveground production in more diverse grassland plots was more stable not only with respect to a rare, major perturbation, drought, but also with respect to more normal year-to-year variation in climate. Native vegetation is the best indicator of the potential productivity of a specific location. The measurement of rangeland herbage standing crop is important in the management of multiple uses such as livestock production, wildlife food and cover, and soil protection against erosion. Yet, herbaceous production in grasslands can be highly variable across years. In eastern Oregon, as Sneva (1982) determined, variability in rangeland productivity is linked to the amount and timing of precipitation received over the winter and early summer. Estimates of aboveground net primary production have been reported for many sites in the Central Grassland region as well as around the world (Lauenroth, 1979). However, few studies in northwestern North America and in Blue Mountain region of northwest have dealt specifically with composition, diversity, and aboveground productivity in prairie ecotypes. Plant species diversity in this study viewed at the alpha level that is the number and relative abundance of species within a particular habitat type

(Whittaker, 1975). The objective of this study was to determine the productivity, species composition, and diversity of a bunchgrass prairie in northeastern Oregon.

Materials and Methods

Study Area

The study was conducted from late June to late July between 2004 and 2006 on the Zumwalt Prairie which is the largest remnant of the northwest bunchgrass ecosystem type (Tisdale, 1982). Our study area was within the prairie at The Nature Conservancy's (**TNC**) Zumwalt Prairie Preserve (lat 45°34′N, long 122°57′W) which is located near the city of Enterprise in northeastern Oregon (Damiran et al., 2007). The area is on a basalt plateau at an elevation of 1340 to 1460 m with little relief (mean slope = 7%) and receives around 330 mm of precipitation annually (30-year average) with a distinct dry period in July and August. Precipitation is bimodal, falling in spring as localized thunderstorms and in winter as snow. Long-term average annual temperature (30-year average) is 6.4°C, and ranged from -2.8°C (December) to 17.1°C (July). Precipitation and temperature data (NOAA, 1957-1987) were from the Enterprise, Ore. weather station at 1163 m elevation located northwest (<30 km) of the study area. Soils are mostly shallow to moderate deep silt loams with patchy influence of loess. Small areas of shallow and very shallow rocky soils occur on ridgetops and upper hillslopes (USDA, NRCS, TNC, unpublished data). The vegetation is dominated by native bunchgrasses that include Idaho fescue (*Festuca idahoensis* Elmer), prairie Junegrass (*Koeleria macrantha* [Ledeb.] J.A. Schultes), and bluebunch wheatgrass (*Pseudoroegneria spicata* [Pursh] A. Löve). The study area has grazed for over 100 yr and in the past >50 yr as spring/summer pasture for cattle (P. Shephard, personal communication). Native ungulates (*Odocoileus hemionus*, *Cervus elaphus*) and Belding's ground squirrels (*Spermophilus beldingi*) are also common. Plant species nomenclature and separating plants by growth form, life span, and origin throughout this paper follow the recommendations of the USDA Natural Resources Conservation Service (USDA, NRCS, 2007).

Experimental Design

This study was conducted as a part of a larger, multi-disciplinary study examining the effects of livestock stocking rates on the grassland food web. There were four blocks of land 160 ha in size, and within each block, four contiguous paddocks were partitioned, each 40 ha in size. The data summarized here are based on the pre-treatment sampling of vegetation that was conducted in the blocks in 2004 and 2005 and in the paddocks in 2006. Within each paddock, we established a set of 36 sampling points. This resulted in for a total of 576 sampling points available for clipping for production, and 1152 for estimating canopy cover (two plots per sampling point).

Percent Cover

Canopy cover was measured in a rectangular frame (0.5 × 1 m, 0.5 m^2) on 1152 plots by ocular estimation (Daubenmire, 1959). Cover classes were: 0 = 0%, 1 = 0.01-1%, 2 = 1.1-5%, 3 = 5.1-25%, 4 = 25.1-50%, 5 = 50.1-75%, 6 = 75.1-95%, 7 = 95.1-99%, and 8 = 99.1-100% and converted to the midpoint percentage of the estimate. Canopy cover was estimated for each vascular plant species having canopy within plot boundaries. Cover values of species in the same functional group within the same plot were added together to create total cover values for these groups. The sum of cover values exceeded 100% due to canopy overlap. We estimated the amount of the soil surface falling into the following 7 categories: bare ground, herbaceous litter, woody litter >5 mm diameter, rock fragment >5 mm, bedrock, bryophyte, and lichen or other biological soil crust.

Standing Crop

We monitored herbaceous productivity of the prairie for 3 consecutive years during 2004, 2005, and 2006. We separated current year's crop from total standing crop to quantify year effects to annual productivity. Clipped standing crop data were collected from each sampling point at peak production, in late June of 2004 and 2005 and from late June to late July of 2006. All vegetation within the rectangular frame was clipped at ground level. Clipped samples were separated into live and dead materials, the latter was discarded. Live material (standing crop) was further separated by species, oven dried at 60°C, and weighed. Total standing crop of each sampling point was determined by summing the aboveground biomass of all species removed from each plot and expressed in $kg \cdot ha^{-1}$. Data by species were placed into functional groups based on plant growth form, life cycles, and origin (i.e., native or exotic).

Species Diversity and Frequency

Diversity was calculated using three indices: richness, the total number of species (S) tallied per 0.5 m^2 plot or site, heterogeneity ($\boldsymbol{H}$), and evenness ($\boldsymbol{E_H}$) estimated by the Shannon-Wiener formula (Krebs, 1972), where, $H = -\Sigma\, p_i \ln\, p_i$ and p_i – the relative percentage of standing crop of individual species on each plot or site. Standing crop was used as a measure of species abundance in diversity calculations. Heterogeneity index considers both richness and evenness components of diversity; that is, the number of species and evenness of their abundance. Species frequency was calculated as the number of times (or plots) an individual species is present in the study sites.

Data Analysis

Standing crop and cover, as well as the measurements summed by growth form were generated and separated using MIXED procedure of SAS (SAS, 2002).

Results and Discussion

Frequency of Occurrence

Native grasses dominated the species composition of the study area; Idaho fescue, prairie Junegrass, and bluebunch wheatgrass constituted 84.2, 68.8, and 63.4% frequency of occurrence, respectively. In contrast, the most common introduced species was Kentucky bluegrass (*Poa pratensis* L.) at 43.4% frequency. Western yarrow (*Achillea millefolium* L. var. *occidentalis* DC.) (55.7%) was prevalent among forbs, followed by tall annual willowherb (*Epilobium brachycarpum* K. Presl) (47.7%) and twin arnica (*Arnica sororia* Greene) (47.4%). The shrub component was well presented by two subshrub species: silky lupine (*Lupinus sericeus* Pursh) (58.0%) and slender cinquefoil (*Potentilla gracilis* Dougl. ex Hook.) (44.8%). Dwarf (*Rosa gymnocarpa* Nutt.) and Nootka roses (*Rosa nutkana* K. Presl.) (1%) and common snowberry (*Symphoricarpos albus* [L.] Blake) (0.5%) occurred only occasionally.

Species Diversity

Heterogeneity (richness combined with equitability) of an ecosystem is important, but relative abundance or evenness of taxa is frequently viewed as more important to land resource managers than richness. In nature, biomass and number of individuals are almost never evenly distributed between species (Wilson et al., 1996). Evenness, as described Mulder et al. (2004), is the relative contribution of each species to the total biomass or number of individuals. A total of 186 vascular plant species was found across the study sites with 13 species being the average number per plot. Although the total number of plant species found in the study was higher than that was observed on the prairie of Minnesota (132 species), the number of species per plot was lower than those reported on the same prairie (15 to 18) and on the rough fescue grasslands of

Montana (18 to 19) (Tilman, 1993; Short and Knight, 2003). A confounding feature about species richness according to West (1993) was that the actual number of species (***S***) present in the sampling universe is difficult to know because *S* is usually underestimated from subsampling, whereas equitability is usually overestimated. Shannon diversity index was 1.8 with evenness in species abundance being 0.7 for the study area. On Kansas native tallgrass prairie Shannon diversity indices were around 2.0 to 3.0 (Hickman et al., 2004; Gene Towne and Kemp, 2003). Almost 80% of the plant species found in our study were native perennial species. Most notable on this grassland community was the remarkable diversity of forbs accounting for 119 species or 64% of the total number of species in the area. In addition, 36 or 19% of the total number of species were invading and/or introduced species.

Canopy Cover

Total canopy cover of vegetation was 104.6 ± 5%. The grass/grasslike component cover was highest (56.5 ± 3%), followed by the forb component (35.6 ± 3%), with shrubs contributing least (12.5 ± 3%) to the total canopy cover ($P < 0.05$). Difference in mean percent cover between the growth forms was as high as 21-23%. At individual species level, the most abundant species by canopy coverage was Idaho fescue (21.9%) followed by bluebunch wheatgrass (10.7%), and Kentucky bluegrass (5.8%). Old man's whiskers (*Geum triflorum* Pursh) contributed most (6.3%) to the forb cover with twin arnica (4.2%) and hoary balsamroot (*Balsamorhiza incana* Nutt.) (3.5%) also contributing to cover. Shrub component contained substantial canopy coverage of silky lupine (6.3%) and slender cinquefoil (4.8%). Stohlgren et al. (1998) found mean foliar cover of native species to be 28.7 to 36.3% and of exotic species 8.2 to 9.0% in the Central Grasslands. The ground surface layer is an important component of a habitat type (Table 1). The study sites had relatively high herbaceous litter and low lichen or biological crust, but no woody litter or bedrock. Litter could be readily separated according to whether it originated from the plants of the herbaceous or woody layers since in the prairie virtually all of the dead organic material overlying the soil was not decomposed due to dry conditions. The estimate for bare ground cover (16.6%) in this study was lower compared to that was observed on the shortgrass steppe of northeastern Colorado (30 to 70%) by Guenther and Detling (2003). Bare ground found on this rangeland was less than 30%, which has been suggested as the maximum acceptable level for adequate soil erosion protection (Hofmann and Ries, 1988). However, according to Johnston (1962) when bare ground is approximately 15% hydrologic changes such as reduced infiltration and increased runoff occur in mixed prairie and fescue grassland ecosystems.

Standing Crop

Standing crops on the prairie varied ($P < 0.05$) across years. The highest production (1928 ± 92 $kg \cdot ha^{-1}$) was obtained in 2005, whereas lower standing crops ($P > 0.05$) were measured in 2004 and 2006 (1381 ± 92 and 1262 ± 92 $kg \cdot ha^{-1}$, respectively). Graminoids contributed most to the total standing crop (701 ± 26 $kg \cdot ha^{-1}$), forbs were the next most abundant group with 416 ± 26 $kg \cdot ha^{-1}$ and shrubs produced 144 ± 26 $kg \cdot ha^{-1}$ ($P < 0.05$). Native perennials made up 79% of the total standing crop with introduced perennials contributing 12%. Annuals contributed less to total production with native and introduced species making up 3 and 4%, respectively. Species with the highest standing crop was Idaho fescue (217 $kg \cdot ha^{-1}$) with bluebunch wheatgrass producing the next highest amount (163 $kg \cdot ha^{-1}$). Kentucky bluegrass introduced a substantial amount (98 $kg \cdot ha^{-1}$) of herbage to total production. Contribution of old man's whiskers was also significant (123 $kg \cdot ha^{-1}$), with other forbs such as hoary balsamroot (35 $kg \cdot ha^{-1}$), twin arnica (26 $kg \cdot ha^{-1}$), and western yarrow (25 $kg \cdot ha^{-1}$) making in lesser amounts. At seven grassland sites in

North America and Europe, Bakker et al. (2006) divided their experimental sites into two classes of low (0-300 $g \cdot m^{-2}$) and high (300-600 $g \cdot m^{-2}$) productivity. In doing so they refer to that the threshold of 300 $g \cdot m^{-2}$ corresponds roughly to the biomass above which light penetration to the soil surface is <5% and thus limiting to the establishment of many plant species (Huisman and Olff, 1998). The estimate for production on the bunchgrass prairie (125.5 $g \cdot m^{-2}$) in this study (2006) was essentially identical to what Bakker et al. (2006) found on the bunchgrass steppe of Utah (125 $g \cdot m^{-2}$). Production values for 2004 and 2006 were lower as compared to those reported on the rough fescue grasslands in southern Alberta (Willms and Rode, 1998) and for the Central Grassland region (Sala et al., 1988) but higher than that of a northwest bunchgrass site (Sims and Singh, 1978). Dry environments on infertile soils have low productivity and favor plants that compete well for both nutrients and water in the absence of herbivory (Olff and Ritchie, 1998). Furthermore, annual productivity by Ovington et al. (1963) is not synonymous with plant biomass or with gross changes in plant biomass from year to year and for a plant community it is composed of many different species and individuals of the same species which do not necessarily attain their greatest individual weights at the time of maximum community biomass.

Implications

Characteristics of the native bunchgrass prairie as measured by standing live crop, plant diversity, and cover as it relates to wildlife species could be incorporated into future livestock or wildlife and conservation management decisions. The study show that the current year's standing crop on the northwestern bunchgrass prairie can vary greatly from year to year and be lower than on the other grasslands. Percent bare ground and invading and/or introduced species found in this study should be of practical significance since they could be indicative of hydrologic and range condition changes occurring in the ecosystem. In respect to the larger study (food web study), the results from this study will be used to refine the study design on the stocking rates and provide a baseline analysis of vegetation production, canopy cover, and frequency, how these variables are influenced by cattle stocking rates, and for the study of vegetation-soils and vegetation-grazing relations.

Literature Cited

Bakker, E. L., M. E. Ritchie, H. Olff, D. G. Milchunas, and J. M. H. Knops. 2006. Herbivore impact on grassland plant diversity depends on habitat productivity and herbivore size. Ecol. Lett. 9:780-788.

Collins, S. L. 1992. Fire frequency and community heterogeneity in tallgrass prairie vegetation. Ecology. 73:2001-2006.

Damiran, D., T. DelCurto, E. Darambazar, A. A. Clark, P. L. Kennedy, and R. V. Taylor. 2007. Visual obstruction: weight technique for estimating production on northwestern bunchgrass prairie rangelands. Proc. West. Sec. of Amer. Soc. Anim. Sci. 58: (in press).

Daubenmire, R. 1959. A Canopy-coverage method of vegetational analysis. Northwest Science. 33:43-64.

Gene Towne, E., and K. E. Kemp. 2003. Vegetation dynamics from annually burning tallgrass prairie in different seasons. J. Range Manage. 56:185-192.

Guenther, D. A., and J. K. Detling. 2003. Observations of cattle use of prairie dog towns. J. Range Manage. 56:410-417.

Hickman, K. R., D. C. Hartnett, R. C. Cochran, and C. E. Owensby. 2004. Grazing management effects on plant species diversity in tallgrass prairie. J. Range Manage. 57:58-65.

Hofmann, L., and R. E. Ries. 1988. Vegetation and animal production from reclaimed mined land pastures. Agron. J. 80:40-44.

Huisman, J., and H. Olff. 1998. Competition and facilitation in multispecies plant-herbivore systems of productive environments. Ecol. Lett. 1:25-29.

Johnston, A. 1962. Effects of grazing intensity and cover on the water-intake rate of fescue grassland. J. Range Manage. 15:79-87.

Krebs, C. J. 1972. The experimental analysis of distribution and abundance. Harper & Row, Publishers, New York, N.Y.

Lauenroth, W. K. 1979. Grassland primary production: North American grasslands in perspective. Pages 3-24 in N. R. French, ed. Perspectives in grassland ecology, Ecol. Studies, Vol. 32, Springer-Verlag, New York, N.Y.

Mulder, C. P. H., E. Bazeley-White, P. G. Dimitrakopoulos, A. Hector, M. Scherer-Lorenzen, and B. Schmid. 2004. Species evenness and productivity in experimental plant communities. OIKOS. 107:50-63.

NOAA. 1957-1987. Climatological data. Annual report for Oregon. National Climatic Data Center, Ashville, N.C.

Olff, H., and M. E. Ritchie. 1998. Effects of herbivores on grassland plant diversity. TREE. 13:261-265.

Ovington, J. D., D. Heitkamp, and D. B. Lawrence. 1963. Plant biomass and productivity of prairie, savanna, oakwood, and maize field ecosystems in central Minnesota. Ecology. 44:52-63.

Sala, O. E., W. L. Parton, L. A. Joyce, and W. K. Lauenroth. 1988. Primary production of the central grassland region of the United States. Ecology. 69:40-45.

SAS. 2002. SAS/STAT guide for personal computer. Version 9.1. SAS Institute, Cary, N.C.

Short, J. J., and J. E. Knight. 2003. Fall grazing affects big game forage on rough fescue grasslands. J. Range Manage. 56:213-217.

Sims, P. L., and J. S. Singh. 1978. The structure and function of ten Western North American grasslands: II. Intra-seasonal dynamics in primary producer compartments. J. Ecology. 66:547-572.

Sneva, F. 1982. Relation of precipitation and temperature with yield of herbaceous plants in eastern Oregon. Int. J. Biometeorology. 26:263-276.

Stohlgren, T. J., K. A. Bull, Y. Otsuki, C. A. Villa, and M. Lee. 1998. Riparian zones as havens for exotic plant species in the central grasslands. Plant Ecology. 138:113-125.

Tilman, D. 1993. Species richness of experimental productivity gradients: how important is colonization limitation? Ecology. 74:2179-2191.

Tisdale, E. W. 1982. Grasslands of western North America: The Pacific Northwest Bunchgrass. Pages 232-245 in Grassland ecology and classification. Symp. Proc. British Columbia Ministry of Forests, A. C. Nicholson, A. McLean, and T. E. Baker, ed. Kamloops, BC, Canada.

USDA, NRCS. 2007. The PLANTS database. Version 3.5. Available: http://plants.usda.gov. Accessed Jan. 22, 2007.

West, N. E. 1993. Biodiversity of rangelands. J. Range Manage. 46:2-13.

Whittaker, R. H. 1975. Communities and ecosystems. MacMillan, New York, N.Y.

Willms, W. D., and L. M. Rode. 1998. Forage selection by cattle on fescue prairie in summer or winter. J. Range Manage. 51:496-500.

Wilson, J. B., T. C. E. Wells, I. C. Trueman, G. Jones, M. D. Atkinson, M. J. Crawley, M. E. Dodd, and J. Silvertown. 1996. Are there assembly rules for plant species abundance? An investigation in relation to soil resources and successional trends. J. Ecology. 84:527-53.

Table 1. Percent cover of the ground surface layer on the Zumwalt Prairie Preserve in northeastern Oregon for 2006 (n = 1152)

	Bare Ground	**Herbaceous Litter**	**Woody Litter**	**Bryophyte**	**Lichen or Biocrust**	**Rock Fragment**	**Bedrock**
Mean ± SEM	16.6 ± 1.7	32.9 ± 1.6	0	10.3 ± 0.8	1.1 ± 0.2	3.8 ± 0.6	0