Environmental Factors that Affect Range Plant Growth, 1892-2006

Llewellyn L. Manske PhD
Range Scientist
North Dakota State University
Dickinson Research Extension Center

Environmental factors affect range plant growth. The three most ecologically important environmental factors affecting rangeland plant growth are light, temperature, and water (precipitation). Plant growth and development are controlled by internal regulators that are modified according to environmental conditions. A research project was conducted to describe the three most important environmental factors in western North Dakota and to identify some of the conditions and variables that limit range plant growth. Rangeland managers should consider these factors during the development of long-term management strategies (Manske 2007).

Light is the most important ecological factor affecting plant growth. Light is necessary for photosynthesis, and changes in day length (photoperiod) regulate the phenological development of rangeland plants. Changes in the day length function as the timer or trigger that activates or stops physiological processes initiating growth and flowering and that starts the process of hardening for resistance to low temperatures in fall and winter. The tilt of the earth's axis in conjunction with the earth's annual revolution around the sun produces the seasons and changes the length of daylight in temperate zones. Dickinson (Fig. 1) has nearly uniform day and night lengths (12 hours) during only a few days, near the vernal and autumnal equinoxes, 20 March and 22 September, respectively, when the sun's apparent path crosses the equator as the sun travels north or south, respectively. The shortest day length (8 hours, 23 minutes) occurs at winter solstice, 21 December, when the sun's apparent path is farthest south of the equator. The longest day length (15 hours, 52 minutes) occurs at summer solstice, 21 June, when the sun's apparent path is farthest north of the equator. The length of daylight changes during the growing season, increasing from about 13 hours in mid April to nearly 16 hours in mid June, then decreasing to around 11 hours in mid October (Fig. 1).

Temperature, an approximate measurement of the heat energy available from solar radiation, is a significant factor because both low and high temperatures limit plant growth. Most plant biological activity and growth occur within only a narrow range of temperatures, between 32° F (0° C) and 122° F (50° C). The long-term (115-year) mean annual temperature in the Dickinson, North Dakota, area is 40.8° F (4.9° C) (Table 1). January is the coldest month, with a mean temperature of 11.4° F (-11.5° C). July and August are the warmest months, with mean temperatures of 68.7° F (20.4° C) and 67.0° F (19.4° C), respectively. Months with mean monthly temperatures below 32.0° F (0.0° C) are too cold for active plant growth. Low temperatures define the growing season for perennial plants, which is generally from mid April to mid October (6.0 months). Perennial grassland plants are capable of growing for longer than the frost-free period, but to continue active growth, they require temperatures above the level that freezes water in plant tissue and soil. Winter dormancy in perennial plants is not total inactivity but reduced activity.

Water (precipitation) is essential for all plants and is an integral part of living systems. Water is ecologically important because it is a major force in shaping climatic patterns and biochemically important because it is a necessary component in physiological processes. Plant water stress limits growth. Water stress can vary in degree from a small decrease in water potential to the lethal limit of desiccation. The long-term (115-year) annual precipitation for the area of Dickinson, North Dakota, is 16.03 inches (407.16 mm). The growing season precipitation (April to October) is 13.57 inches (344.43 mm), 84.59% of the annual precipitation. June has the greatest monthly precipitation, at 3.57 inches (90.64 mm). The seasonal distribution of precipitation (Table 2) shows the greatest amount of precipitation occurring in the spring (7.31 inches, 45.63%) and the smallest amount occurring in winter (1.54 inches, 9.62%). Total precipitation received in November through March averages less than 2.5 inches (15.35%). The precipitation received in May, June, and July accounts for 50.66% of the annual precipitation (8.12 inches).

Of the past 115 years (1892 to 2006), 14 (12.17%) were drought years, receiving 75% or less of the long-term mean precipitation level. Fifteen (13.04%) were wet years, receiving 125% or more of the long-term mean precipitation level. Eighty-six years (74.78%) received normal annual precipitation amounts, between 75% and 125% of the long-term mean. Of the past 115 growing seasons, 17 (14.78% were drought growing seasons, 20 (17.39%) were wet growing seasons, and 78 (67.83%) received precipitation at normal levels.

Temperature and precipitation act together to affect the physiological and ecological status of range plants. The balance between rainfall and potential evapotranspiration determines a plant's biological situation. When rainfall is lower than evapotranspiration demand, a water deficiency exists. The ombrothermic graph technique (Emberger et al. 1963), which plots mean monthly temperature and monthly precipitation on the same axis, was used to identify months with water deficiency conditions during 1892-2006 (Manske 2007). The long-term ombrothermic graph for the Dickinson area (Fig. 2) shows near water deficiency conditions for August, September, and October, a finding indicating that range plants generally may have difficulty growing and accumulating biomass during these 3 months. Favorable water relations occur during May, June, and July, a period during which range plants should be capable of growing and accumulating herbage biomass.

Drought years occurred during 12.2% of the past 115 years, and 14.8% of the growing seasons were drought growing seasons. The 115-year period (1892 to 2006) contained a total of 690 growing- season months. Water deficiency conditions occurred during 226.5 of these, a finding indicating that during 32.83% of the growing season months, or for an average of 2.0 months during every 6.0-month growing season, range plants were under water stress and therefore limited in growth and herbage biomass accumulation. Water deficiency occurred in May and June 13.9% and 10.4 % of the time, respectively. Water deficiency conditions occurred in July less than 40% of the time. Water deficiency conditions occurred in August, September, and October more than 50% of the time: 52.2% of the time in August, 50.4 % of the time in September, and 47.0% of the time in October. Water deficiency conditions lasting a month or more cause plants to experience water stress severe enough to reduce herbage production. These levels of water stress are a major factor limiting the quantity and quality of plant growth in western North Dakota and can limit livestock production if not considered during the development and implementation of long-term grazing management strategies.

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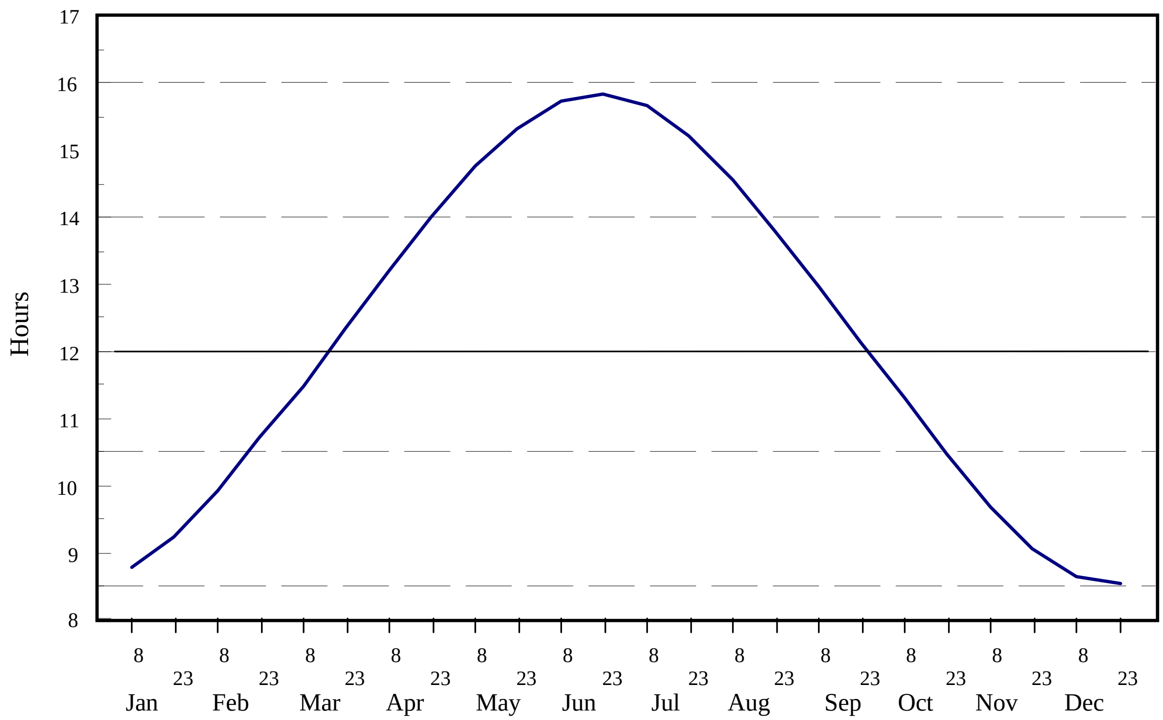

Fig. 1. Annual pattern of daylight duration at Dickinson, North Dakota.

Table 1. Long-term (1892-2006) mean monthly temperature and monthly precipitation at Dickinson, ND.

	º F	º C	in.	mm
Jan	11.39	-11.45	0.41	10.52
Feb	15.29	-9.28	0.40	10.18
Mar	26.09	-3.29	0.73	18.45
Apr	41.60	5.34	1.43	36.22
May	52.79	11.55	2.32	58.93
Jun	61.99	16.66	3.57	90.64
Jul	68.71	20.39	2.23	56.74
Aug	66.98	19.44	1.73	43.95
Sep	56.02	13.34	1.33	33.66
Oct	43.75	6.53	0.96	24.29
Nov	28.33	-2.04	0.53	13.57
Dec	17.08	-8.29	0.39	10.01
	MEAN		**TOTAL**	
	40.84	**4.91**	**16.03**	**407.16**

Table 2. Seasonal percentage of mean annual precipitation distribution (1892-2006).

Season	in.	%
Winter (Jan, Feb, Mar)	1.54	9.62
Spring (Apr, May, Jun)	7.31	45.63
Summer (Jul, Aug, Sep)	5.29	33.00
Fall (Oct, Nov, Dec)	1.88	11.76
TOTAL	**16.03**	

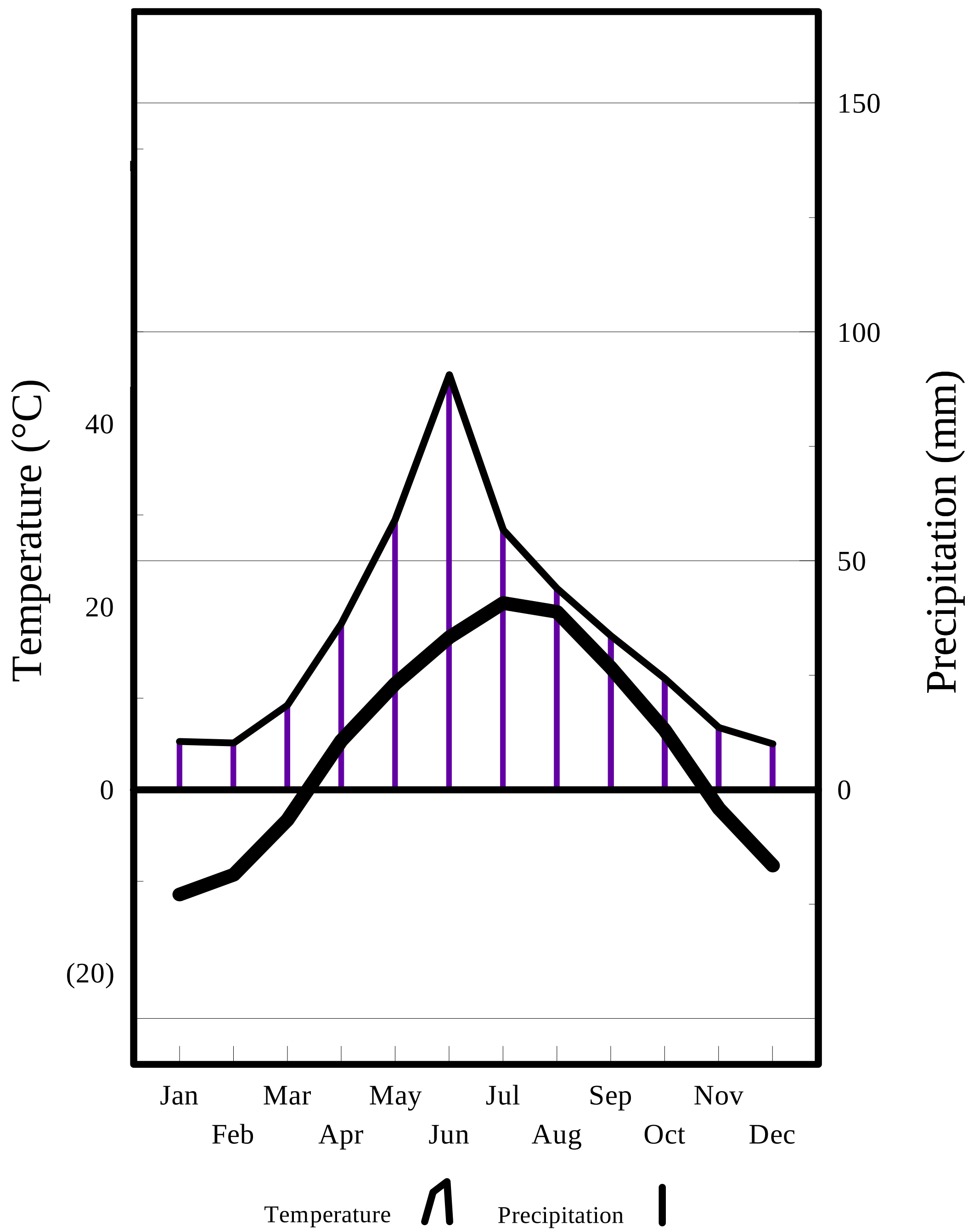

Fig. 2. Ombrothermic diagram of long-term (1892-2006) mean monthly temperature and monthly precipitation at Dickinson, North Dakota.

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Effects on vegetation, endomycorrhizal fungi, and soil mineral nitrogen from prescribed burning treatments repeated every-other-year in mixed grass prairie invaded by western snowberry

Llewellyn L. Manske PhD
Range Scientist
North Dakota State University
Dickinson Research Extension Center

Introduction

Restoration of degraded grassland ecosystems requires the reactivation of the complex biological and ecological processes within native plants and within the rhizosphere organisms that convert soil organic nitrogen into inorganic nitrogen.

The primary cause of deterioration in grassland ecosystems is management practices that are antagonistic to the rhizosphere organism population. Decreases in rhizosphere organism biomass result in reductions in the quantity of organic nitrogen converted into inorganic nitrogen; this conversion is one of the primary functions of rhizosphere organisms. Decreases in the amount of inorganic nitrogen in an ecosystem cause reductions in grass biomass production and decreased native plant density (basal cover), creating larger and more numerous bare spaces between grass plants. These open spaces in the plant community provide ideal habitat for growth of opportunistic “weedy” plant species that are not dependent on the nitrogen converted by rhizosphere organisms. Once established, most opportunistic weedy species have mechanisms that aid in widening the species’ distribution; the spread of the weeds results in further degradation of the grassland ecosystem.

Additions of mineral (inorganic) nitrogen fertilizers to native grassland soils are antagonistic to rhizosphere organism populations, causing greater ecosystem degradation and pushing the plant species composition to be dominated by domesticated cool-season grasses like smooth bromegrass, crested wheatgrass, and Kentucky bluegrass. Other “quick fix” practices that treat only symptoms of the problem and do not correct the cause of the problem also result in further degradation of the ecosystem.

The solution for restoration of degraded grassland ecosystems is to correct the cause of the problem rather than just treat the symptoms of the problem. Grazing management coordinated with grass plant phenological development has been shown to stimulate rhizosphere organism increases in biomass and activity levels (Gorder, Manske, and Stroh 2004, Manske 2005), resulting in increased quantities of inorganic nitrogen (Coleman et al. 1983).

This study was conducted to investigate the possibilities of using prescribed burning treatments in the restoration of degraded mixed grass prairie ecosystems.

Study Area

The study area was the Lostwood National Wildlife Refuge, located in Burke and Mountrail counties in northwestern North Dakota between 48° 50' and 48° 30' north latitude and 102° 40' and 102° 20' west longitude. The landscape is glacial terminal moraine of the Missouri Coteau. Topography is rolling to steep hills interspersed with shallow lakes and prairie wetlands. Soils are primarily fine-loamy, mixed Typic Haploboralls and fine-loamy, mixed Typic Argiboralls. Some areas have sandy or gravelly substratum. Native vegetation is the Wheatgrass-Needlegrass Type (Barker and Whitman 1988) of the mixed grass prairie.

The region was homesteaded between 1910 and 1930. During that period, about 25% of the upland was plowed and used as cropland. Most likely, grazing livestock had access to the remainder of the area. Naturalists’ surveys of the region conducted in 1913-1915 described one lone grove of trees located at the southeastern corner of the refuge’s lower long lake (Smith 1997). The trees were cut down for their wood, and the lake became known as lower Lostwood Lake.

Because of economic troubles of the time, the federal government developed relief programs to repurchase failed homestead land during the mid to late 1930's. The homestead acres repurchased under land utilization projects were designated for three specific purposes. The acres identified for grazing use and economic development from livestock agriculture became the Little Missouri National Grasslands, acres identified for recreational use became Theodore Roosevelt National Park, and acres identified for wildlife use became Lostwood National Wildlife Refuge.