Environmental Factors that Affect Range Plant Growth, 1892-2003

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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 2004).

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 (112-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 11.3°F (-11.5°C). July and August are the warmest months, with mean temperatures of 68.6° 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 (112-year) annual precipitation for the area of Dickinson, North Dakota, is 16.06 inches (407.87 mm). The growing season precipitation (April to October) is 13.59 inches (345.10 mm), 84.62% of the annual precipitation. June has the greatest monthly precipitation, at 3.58 inches (91.04 mm). The seasonal distribution of precipitation (Table 2) shows the greatest amount of precipitation occurring in the spring (7.33 inches, 45.62%) and the smallest amount occurring in winter (1.54 inches, 9.58%). Total precipitation received in November through March averages less than 2.5 inches (15.44%). The precipitation received in May, June, and July accounts for 50.68% of the annual precipitation (8.14 inches).

Of the past 112 years (1892 to 2003), 14 (12.50%) were drought years, receiving 75% or less of the long-term mean precipitation level. Fifteen (13.39%) were wet years, receiving 125% or more of the long-term mean precipitation level. Eighty-three years (74.11%) received normal annual precipitation amounts, between 75% and 125% of the long-term mean. Of the past 112 growing seasons, 18 (16.07%) were drought growing seasons, 20 (17.86%) were wet growing seasons, and 74 (66.07%) 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 1892-2003 (Manske 2004). 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 12.5% of the past 112 years, and 16.1% of the growing seasons were drought growing seasons. The 112-year period (1892 to 2003) contained a total of 672 growing- season months. Water deficiency conditions occurred during 218 of these, a finding indicating that during 32.44% 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 14.3% and 8.9 % 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: 50.9% of the time in August, 50.9 % of the time in September, and 48.2% 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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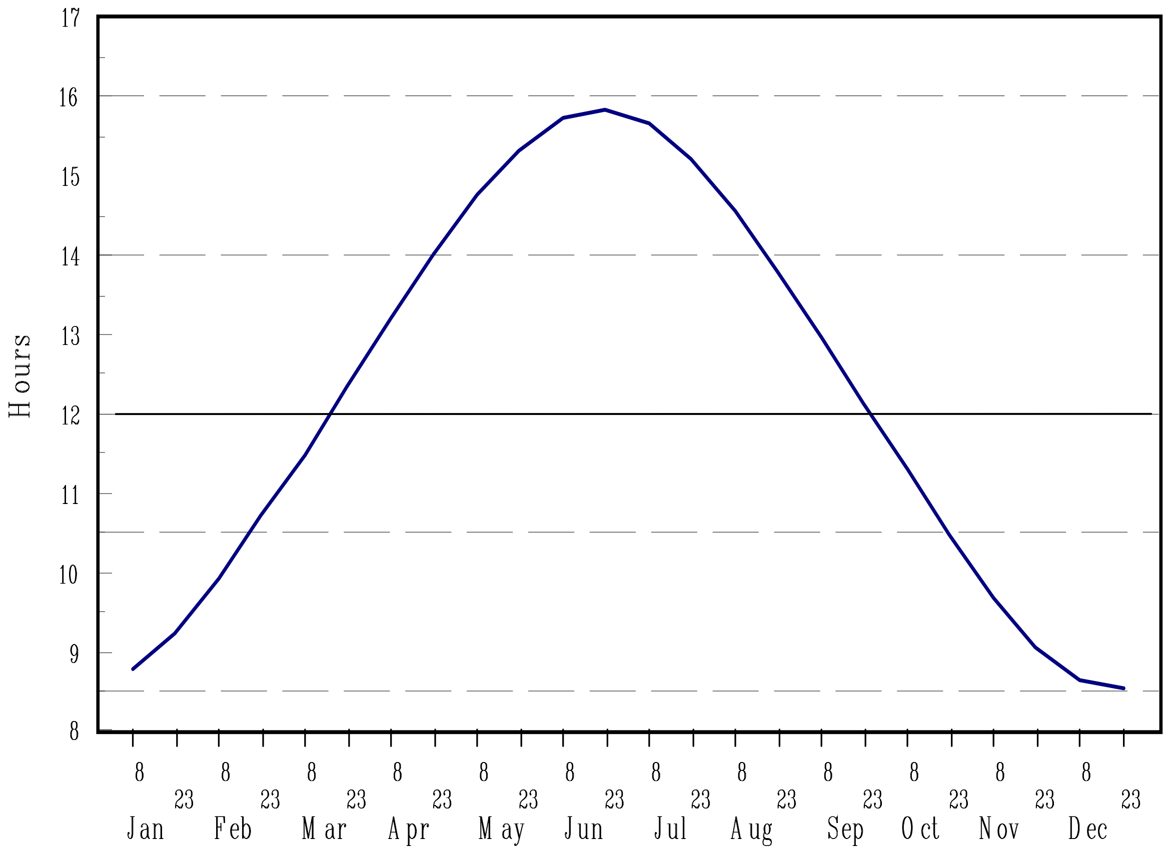

Fig. 1. Annual pattern of daylight duration at Dickinson, North Dakota.

Table 1. Long-term (1892-2003) mean monthly temperature and monthly precipitation at Dickinson, ND.

	° F	° C	in.	mm
Jan	11.27	-11.52	0.41	10.53
Feb	15.13	-9.37	0.41	10.31
Mar	25.95	-3.36	0.72	18.23
Apr	41.49	5.27	1.43	36.32
May	52.83	11.57	2.31	58.72
Jun	61.99	16.66	3.58	91.04
Jul	68.64	20.36	2.25	57.10
Aug	67.00	19.44	1.75	44.47
Sep	55.98	13.32	1.33	33.70
Oct	43.80	6.55	0.94	23.75
Nov	28.22	-2.10	0.54	13.62
Dec	16.98	-8.35	0.40	10.10
	MEAN		**TOTAL**	
	40.77	**4.87**	**16.06**	**407.87**

Table 2. Seasonal percentage of mean annual precipitation distribution (1892-2003).

Season	in.	%
Winter (Jan, Feb, Mar)	1.54	9.58
Spring (Apr, May, Jun)	7.33	45.62
Summer (Jul, Aug, Sep)	5.33	33.16
Fall (Oct, Nov, Dec)	1.87	11.64
TOTAL	**16.06**	

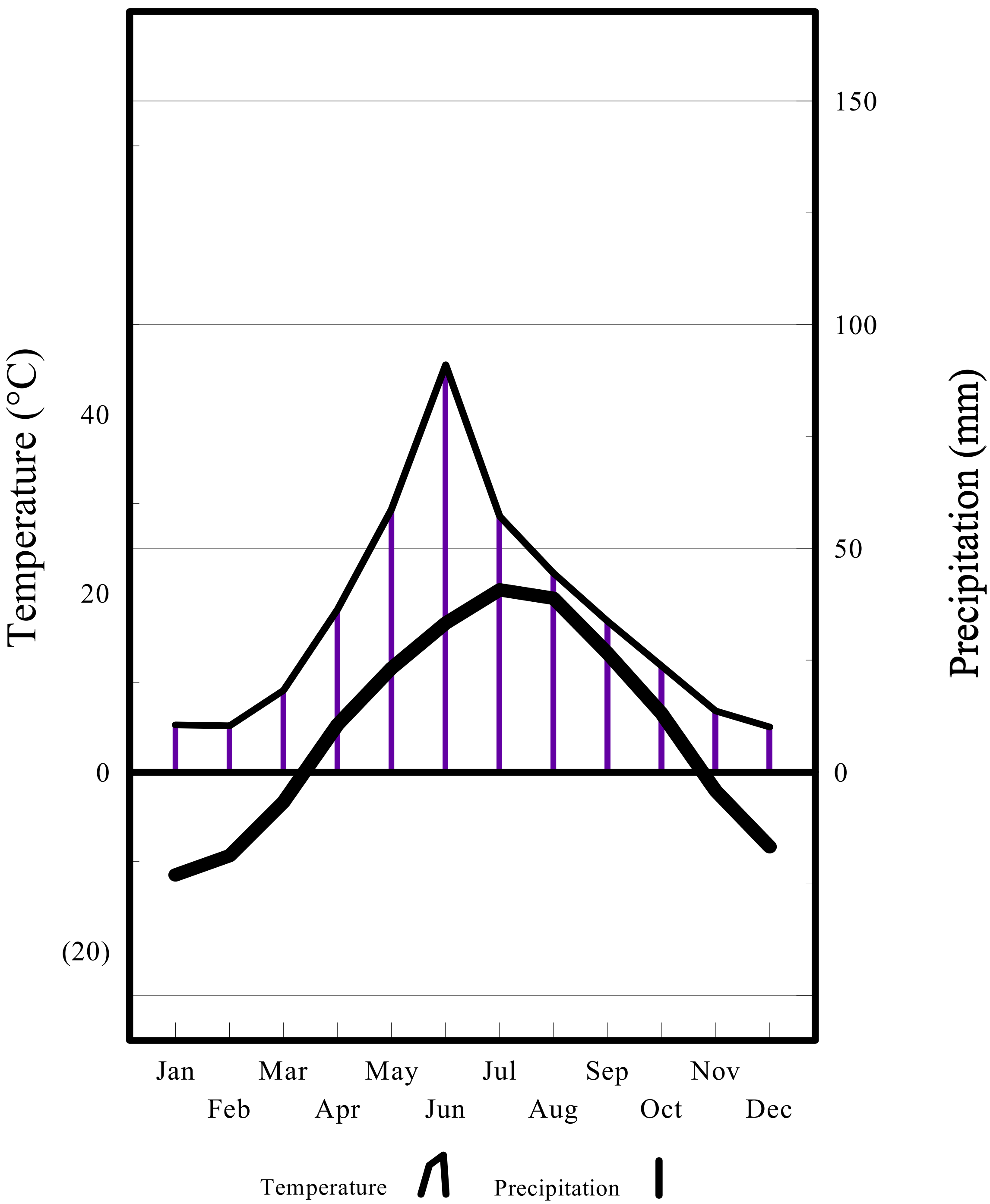

Fig. 2. Ombrothermic diagram of long-term (1892-2003) mean monthly temperature and monthly precipitation at Dickinson, North Dakota.

Literature Cited

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