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ENVIRONMENTAL FACTORS' EFFECTS ON RANGE PLANTS

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Plant growth and development are controlled by internal regulators that are modified according to environmental conditions. The three most ecologically important environmental factors affecting rangeland plant growth are light, temperature, and water (precipitation). These factors require consideration during the development of long-term rangeland management strategies (Manske 1998).

The long-term climatic conditions for a region determine the type of vegetation in that region. The growth and development of the vegetation are affected by regional environmental conditions. Temperature, an approximate measurement of the heat energy available from solar radiation, is a significant factor because most plant biological activity and growth occur within only a narrow range of temperatures, between 32F (0C) and 122F (50C). Water, an integral part of living systems, 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 (Brown 1995). Light is necessary for photosynthesis (the process by which plants convert light energy into chemical energy), and changes in day length (photoperiod) function as the timer or trigger that activates or stops physiological processes initiating growth and flowering and activates the process of hardening for resistance to low temperatures in the fall and winter. Light is the primary factor determining plant phenological development (identifiable growth stages related to time of year) however, temperature and precipitation produce secondary effects and may cause slight variations in the pattern of phenological development.

Both low and high temperatures limit plant growth, and low temperature defines the growing season length. The growing season for annually seeded plants corresponds approximately to the frost-free period, the number of days between the last day with minimum temperatures below 32F (0C) in the spring and the first day with minimum temperatures below 32F (0C) in the fall. The frost-free period for western North Dakota generally lasts 120 to 130 days, from mid to late May to mid to late September (Ramirez 1972). 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 dormanacy in perennial plants is not total inactivity but reduced activity. Many perennial plants begin active growth more than 30 days before the last frost in spring and continue growth after the first frost in fall. The growing season for perennial plants is considered to be between the first 5 consecutive days in spring and the last 5 consecutive days in fall with mean daily temperature at or above 32F (0C). In western North Dakota the perennial plant growing season is considered to be from mid April through mid October (6.0 months or 183 days). Low air temperature during the early and late portions of the growing season and high temperatures after mid summer greatly limit plant growth.

Temperature and precipitation act together to affect the physiological and ecological status of range plants. The balance between rainfall and potential evapotranspiration determines a plants's biological situation. Evaporation rates are dependent on temperature: as average temperature decreases, evaporation rate decreases; as temperature increases, evaporation rate increases. When rainfall is lower than evapotranspiration demand, a water deficiency exists. Under water deficiency conditions, the rate of water loss from transpiration exceeds the rate of water absorption by the roots, and plants undergo water stress, which limits growth. Water stress can vary from a small decrease in water potential (as in midday wilting on warm clear days) to the lethal limit of desiccation. Water stress increases the rate of leaf senescence (aging), which decreases the nutritional quality of the vegetation. Although range plants have mechanisms that help reduce damage from water stress, water deficiency conditions lasting a month cause plants to experience water stress severe enough to reduce herbage production. Thus the annual variation in temperature, evaporation, water stress, and senescence rate is responsible for the variation in quantity and nutritional quality of herbage from year to year.

The ambient climatic conditions in western North Dakota result in frequent periods with plants under water stress. 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 1892-1997. Of the past 106 years, 12.3% have been drought years, receiving 75% or less of the long-term mean precipitation level. Drought growing seasons have occurred during 16.0% of the past growing seasons, and water deficiency conditions have occurred during 33.02% of the growing season months. Because favorable water relations exist during May, June, and July, these months constitute the primary period of production for range plant communities. May and June appear to be the most important months for dependable precipitation: water deficiency conditions have occurred in May and June 15.09% and 9.43% of the time, respectively. July has had water deficiency conditions less than 40% (37.74%) of the time. August, September, and October are not dependable for positive water relations. August and September have had water deficiency conditions for 50.94% and 51.89% of the years, respectively; October has had water deficiency conditions for 49.06% of the years. These months constitute 42% of the growing season, and they have had water deficiency conditions more than half the time. The water relations during this portion of the growing season limit range plant growth and herbage biomass accumulation.

The relationship between temperature and evaporation levels affects the ratio of cool-season to warm-season grasses in the plant species composition. The native vegetation in the Dickinson area generally has a mixture of 60% cool-season and 40% warm-season species. North of the region, the lower average temperature and the lower evaporation rate result in an increase in the percentage of cool-season species. South of the region, the higher average temperature and the greater evaporation rate result in an increase in the percentage of warm-season species. Different plant species have different optimum temperature ranges. Cool-season plants, which have a C_3 photosynthetic pathway, have an optimum temperature range of 50 to 77F (10 to 25C). Warm-season plants, which are C_4 photosynthetic pathway plants, have an optimum temperature range of 86 to 105F (30 to 40C) (Coyne et al. 1995). A mixture of cool- and warm-season species is highly desirable because the herbage biomass production remains more stable over wide variations in seasonal temperatures.

Vegetative growth is triggered by photoperiod and temperature (Langer 1972, Dahl 1995), and reproductive initiation is triggered primarily by photoperiod (Roberts 1939, Leopold and Kriedemann 1975, Dahl 1995) but can be slightly modified by temperature and precipitation (McMillan 1957, Leopold and Kriedemann 1975, Dahl and Hyder 1977, Dahl 1995). 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. Day-length period for a given date and locality remains the same from year to year. Generally, most cool-season plants are long-day plants, and most warm-season plants are short-day plants. Long-day plants reach the flowering stage after exposure to a critical photoperiod and during the period of increasing daylight between mid April and mid June, usually flowering before 21 June. Short-day plants are induced into flowering by day lengths that are shorter than a critical length and that occur during the period of decreasing day length after mid June, usually flowering after 21 June.

The combined influences of light, temperature, and precipitation, affect the quantity and quality of plant growth in western North Dakota and can limit livestock production if not considered during the planning of long-term grazing management strategies. Strategies based on phenological growth stages of the major grasses can be planned by calendar date after the relationships between growth stage of the grasses and time of season have been determined with consideration of a possible variation of about ±7 days to accommodate annual potential modification from temperature and precipitation (Manske 1980). Implementation of such strategies has the potential to maintain the stability of the grassland ecosystem, enhance quantity and quality of herbage, and sustain livestock production.

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