Managing Forages During Extreme Weather

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Good forage production practices involve effective management of appropriate grasses and legumes that fit farm soil and climatic conditions. Mixtures of grasses and legumes provide for yield stability over diverse weather conditions. Forage crop management practices such as fertilization and harvest/grazing management and weed control are important for productive and persistent pastures and hayfields.

Minnesota Climate and Weather Extremes

Minnesota's native forage prairie plants are adapted to the pattern of solar radiation, temperatures, and precipitation. Likewise, introduced forage grasses and legumes should be selected to utilize environmental resources. Minnesota climate is categorized as continental and is influenced by polar air masses in the winter and by air flows from the Pacific and Gulf of Mexico in the summer (Sheaffer and Moncada, 2012). Minnesota has a pronounced theater of seasons (fall, winter, spring, and summer), which vary greatly in precipitation and temperature. The growing season for forage pasture and hay crops (assuming a hard freeze temperature of 24 °F) ranges from 160 days in the north to nearly 200 days in the south (Seeley, 2006). For the east central region of Minnesota, the growing season for pasture grasses and legumes is from about mid-April to late October. For annual crops like corn or sudangrass that are more cold sensitive, the growing season is shorter.

Winter in Minnesota is characterized by cold (below freezing) temperatures while summers tend to be hot (Figure 1). Extreme winter temperatures can directly kill tissue of exposed sensitive crops, but most perennial forage crops adapted to Minnesota have some level of cold tolerance and have crowns or roots protected by soil, plant residue or snow. However, there are often weather patterns with extreme cold or fluctuating temperatures that can be damaging to plants. Spring and fall are times of major weather transition. In the spring, increasing air temperatures promote growth of perennial forages and allow planting of stands of annual and perennial crops; in the fall, low temperatures signal the plant to undergo a dormancy reaction in preparation for winter. Spring and fall typically provide ideal air temperatures and precipitation for growth of "cool season" forage crops. In the summer, heat and humidity predominate in the south, while warm and less humid conditions are generally present in the north. Summer temperatures promote growth of "warm season" plants. Within both grass and legume families (see below), there are both cool and warm season plants. Cool season species such as alfalfa, clovers, and orchardgrass grow best with air temperatures in the range of 55 to 70 °F, while warm season plants such as corn, switchgrass or Illinois bundleflower grow best under warm temperatures or 85 to 95 °F (Sheaffer and Moncada, 2012). Warm season species are usually productive under lower levels of rainfall than cool season species.

Average annual precipitation across the state ranges from around 35 inches in the southeast to 20 inches in the northwest (Baker and Kuehnast. 1978). About two-thirds of the average annual precipitation falls during May through September, which is also the period of greatest forage growth (Figure 2). Snow is the main form of winter precipitation, but freezing rain is possible during the winter months. Melting snow caused by variation in air temperatures during winter

can lead to ice sheeting that is very detrimental to persistence of most forage plants. Persistent snow cover is an important factor in persistence of forages, with 6 inches of snow providing insulation against the coldest of temperatures.

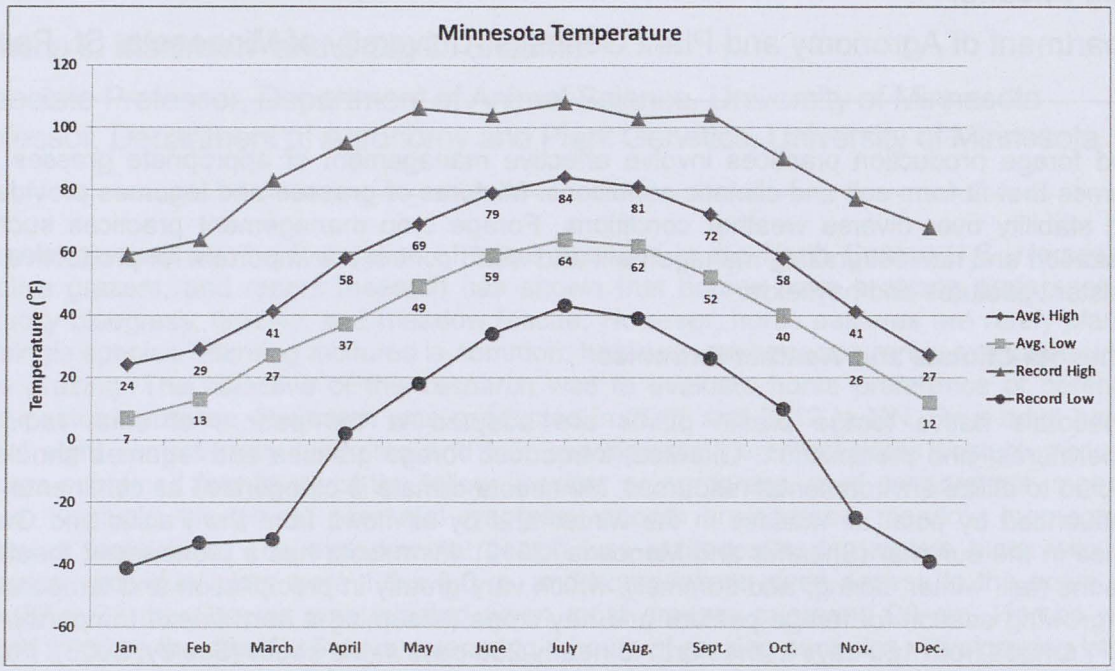

Figure 1. Monthly variation in air temperatures at Minneapolis-St. Paul, Minnesota. Source: National Climatic Data Center. 2013.

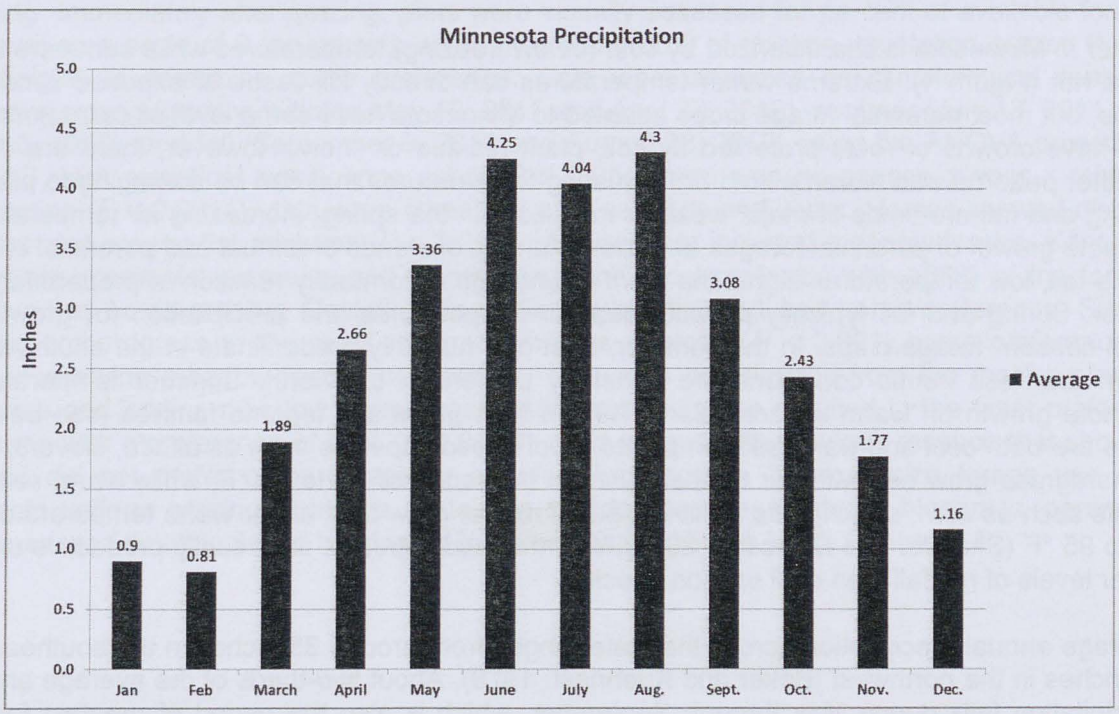

Figure 2. Monthly variation in precipitation at Minneapolis-St. Paul. Source: National Climatic Data Center. 2013.

In most years, periods occur in summer when rainfall and soil moisture levels are unable to meet the water use needs for crops. Moisture limitations, combined with high air temperature, reduce growth rate of crops especially those that fall into the "cool season" category (Figure 3). This "summer slump" limits forage production and utilization of cool season grasses and legumes during July and August of most years. Conditions of severe drought are expected on the average about once in 10 years in the southwest and western Minnesota and once in 25 years in the eastern portion of the state (Seeley, 2006). In the past year, we had unique weather patterns: a statewide drought occurred from mid-summer into fall, a winter that included periods of snow melting, and a prolonged spring that included above-normal rainfall. The fall and winter conditions likely contributed to significant winter injury to alfalfa and pasture grasses like orchardgrass. With climate change, extremes in weather may be more likely (Seeley, 2006).

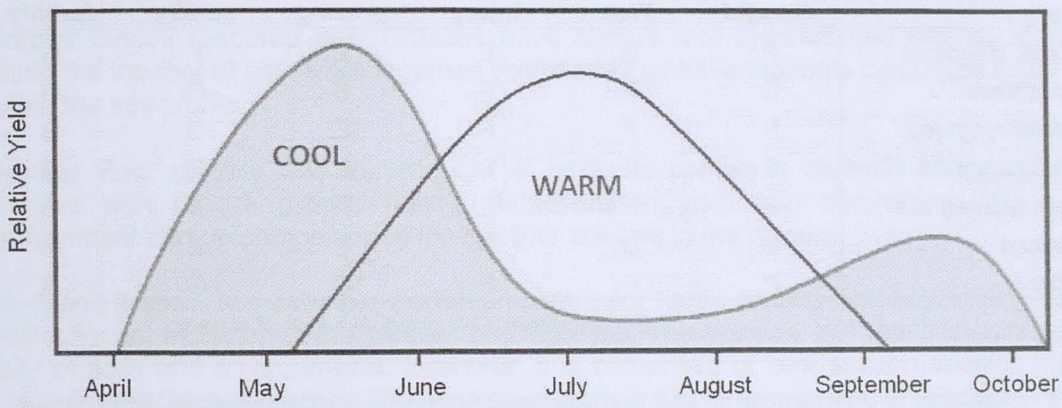

Figure 3 .Distribution of yield from cool and warm season forages species grown in Minnesota. Source: Sheaffer et al., 1995.

Reducing Environmental Risks

We can reduce risks of extreme weather by diversifying plant species we use and through crop management practices. Diversification of plant species can occur by including many plant types in mixtures and by using rotations of crops. Management practices include harvest and grazing strategies, fertilization, and weed control.

Selection of forage species

There are several broad categories of forage plants. Grasses and legumes are two important plant families. Grasses typically have inconspicuous flowers, long- narrow leaves with parallel venation, and fibrous roots. Their seed has one cotyledon. In contrast, legumes have showy flowers, compound leaf arrangements, tap roots, and produce seed in pods. Their seed has two cotyledons. Legumes are unique in that they conduct biological nitrogen fixation of atmospheric nitrogen and consequently do not require the nitrogen fertilization that is required for grass production. Legumes can transfer their fixed nitrogen to grasses growing in mixtures.

Forage legumes and grasses vary in their adaptability to soil and climatic/weather conditions and selection of forage species to fit environmental conditions is an important management strategy (Tables 1 and 2). Among the legumes, alfalfa and white clover are the most persistent under diverse grazing and harvest managements. Alfalfa is the leading hay legume in the Midwest and most often used for hay and silage making. Alfalfa yields in haymaking systems

often range from 3 to 7 tons per acre. White clover is the leading pasture legume in Minnesota and is tolerant of frequent and close grazing. Even so, alfalfa and white clover are both susceptible to winterkill from low temperatures. Alfalfa is also intolerant of wet and acidic soils. Other legumes like red clover and birdsfoot trefoil fit specific use and soil niches such as acidic soils (Sheaffer et al., 2003). Relative to grasses, all legumes require more fertilization with P, K, and S.

Table 1. Tolerance to environmental and management stress by perennial forage grasses. Source: Sheaffer, 2010.

	Tolerance to:					
Grass	Heat or drought	Wet	Winter injury	Cutting or grazing	Soil acidity	Low fertility
Kentucky bluegrass	P	G	E	E	F	G
Orchardgrass	G	F	F	E	G	G
Perennial ryegrass	P	F	P	E	G	G
Reed canarygrass	E	E	E	E	E	G
Smooth bromegrass	E	F	E	P	F	G
Tall fescue	G	G	F	E	E	G
Timothy	P	P	E	P	G	G

E = excellent, G = good, F = fair, P = poor

Table 2. Tolerance to environmental and management stress by forage legumes. Source: Sheaffer, 2010.

	Tolerance to:					
Legume	Heat or drought	Wet	Winter injury	Cutting or grazing	Soil acidity	Low fertility
Alfalfa	E	P	G	G	P	P
Alsike clover	P	E	P	P	G	F
Birdsfoot trefoil	F	E	F	G	G	F
Red clover	F	F	F	F	G	G
White clover	P	G	F	E	G	G

E = excellent, G = good, F = fair, P = poor

Overall, adapted grasses have greater tolerances to extremes of weather, soils and management than legumes. This is in part because the most resilient species like Kentucky bluegrass, smooth bromegrass and even quackgrass are capable of asexual reproduction via rhizomes. Productive species like orchardgrass, tall fescue, and more often perennial ryegrass have tolerance to frequent grazing; however, they are susceptible to winter injury (Allen et al., 2012). Smooth bromegrass and timothy are productive and persistent grasses if infrequently harvested or grazed, but do not persist under intensive grazing systems. Reed canarygrass is especially tolerant of low moisture/wet soils, but will not tolerate continuous or frequent grazing. Grass production is greatly enhanced through the application of nitrogen fertilizers.

Forage mixtures

While individual forage species provide the opportunity to maximize production in a specific environment, monocultures of single species also provide the greatest risks to loss of production due to environmental extremes. For example, while orchardgrass was found to be among the most productive and persistent grasses under horse grazing in St. Paul (Allen et al., 2012), it suffered near complete stand loss because of injury during the winter of 2012-2013. Therefore, producers in southern Minnesota who relied on orchardgrass monocultures were faced with a lack of pastures in the spring of 2013. Likewise, many alfalfa hay producers have been struggling to find alternative sources of alfalfa forage because of winter injury to alfalfa.
Growing a diversity of plants in mixtures provides several advantages compared to pure stands. These advantages in tolerance to weather extremes include:

- Greater overall resource use: Grasses have fibrous root systems that use water mostly within the top foot of soil, while legumes like alfalfa that have tap roots can utilize water deep within the soil profile.

- Greater yield stability and survivability: If mixtures contain a diversity of legumes and grasses with unique growth habits, reductions in yield and persistence due to the environment can be compensated for by other species in the mixture.

Tables 3 and 4 show two example mixtures suitable for horse grazing and haymaking, as well as justification for inclusion of the grasses and legumes. The example in Table 3 is suitable for a diversity of soils and environments. However, it is comprised of cool season species that will yield best in the fall and spring. The mixture shown in Table 4 is particularly adapted to wet soils.

Table 3. Example of a diverse horse pasture mixture for upland soils.

Forage	Rate (lb/acre)	Rationale
Orchardgrass	4	Yield
Meadow fescue	5	Yield, palatability
Perennial ryegrass	3	Nurse crop
Kentucky bluegrass	3	Persistence
White clover or alfalfa	3	N fixation

Table 4. Example of a diverse horse pasture mixture for wet soils.

Forage	Rate (lb/acre)	Rationale
Reed canarygrass	6	Persistence
Perennial ryegrass	3	Nurse crop
Birdsfoot trefoil	4	N fixation
Alsike clover	1	N fixation

Alternative crops

Emergency crops. For emergency pasture and hay production following pasture winterkill, annual cool and warm season grasses can be seeded and, if harvested at vegetative stages, can provide 2 to 4 tons/acre of forages (Peterson et al., 2003; Schmeider, 2013). Of the many

options, small grains and Italian ryegrass deserve mention. Small grains such as oat and wheat that are commonly used, can be spring seeded, and will provide forage from 1 or 2 harvests. For season-long grazing, Italian ryegrass is a vigorous, leafy, high-quality, cool season grass. Italian ryegrasses will not produce seed heads in the seeding year. Small grains and ryegrass will die during the winter.

Warm season prairie plants. Native warm season grasses like big bluestem and Indiangrass grown in mixture with legumes and forbs are used in prairie restoration projects and are sometimes available for haying and grazing. They are heat and drought tolerant and provide forage during mid-summer from June through August, a time when the productivity of cool season species is usually limited. Yields from established stands can range from 2 to 4 tons per acre. They also require lower levels of soil fertility than most cool season grasses and legumes. However, warm season prairie plants are not well suited for intensive utilization. Under most Minnesota conditions, harvesting should be limited to a single hay harvest or 2 cycles of grazing. Haying or grazing should leave about 6 inches of stubble to facilitate regrowth.

Management strategies

Healthy plants with strong root systems have greater tolerance to a diversity of environmental pressures than stressed plants. An overall strategy is to manage forages using practices that will provide productive yet healthy stands.

Grazing or hay management. Persistence and yield of forage plants is strongly related to the accumulation of energy reserves in roots and stem bases. Reserves typically go through a cyclic pattern of accumulation during regrowth following cutting, but are depleted during initiation of subsequent cutting and initiation of regrowth. Therefore, in grazing systems, persistence of most upright growing species is insured by rotational grazing (Undersander et al., 2002). Intervals of grazing are typically from 3 to 4 weeks depending on the growing conditions. When drought limits pasture productivity, do not stress pasture grasses and legumes by continuing to graze. Maintain a minimum grazing height of 3 inches, and if forages do not regrow following defoliation, remove horses to a sacrifice paddock.

Fertilization. The major nutrients such as N, P, K and micronutrients such as S and B are important in maintaining healthy plants. Healthy, well-fertilized plants have greater tolerance to environmental stress due to cold and drought. Soil test and fertilizer recommendations are available from the University of Minnesota Soil Testing Laboratory (http://soiltest.cfans.umn.edu/).

Weed control. Weeds or unwanted plants compete with forage plants for soil nutrients, water, and light. Therefore, weed control using mowing or herbicides will also improve forage yield and plant tolerance to stress. See *Weed Control in Pastures* (http://www.extension.umn.edu/beef/components/homestudy/plesson4.PDF) for more information.

Summary

Cool season grass and legume forage crops are important to provide pasture and hay for horses and other livestock. Minnesota's climate allows for growth from May through October with challenges to yield and persistence from drought during summer months and to stand persistence during winter. These climatic and weather-related challenges can be lessened by proper species selection, use of plant mixtures, and by management practices such as rotational grazing, fertilization, and weed control.

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