Evaluating Grass Development for Grazing Management.

A. B. Frank

Management decisions based on plant growth and development can be beneficial to the overall health of the grass stand. Initiation of spring grazing is critical to the season-long vigor and productivity of grasses. Early grazing reduces plant leaf area and photosynthesis which is needed to replace carbohydrates depleted over winter and during greenup. As a consequence plant vigor is reduced, stands are thinned, total forage production is decreased, and disease, insect, and weed infestations are increased. Pastureland and rangeland damaged by early grazing may require several years of rest to regain productivity. On the other hand, late grazing increases forage loss and waste through trampling or reduced palatability and decreased nutritional value.

Grazing readiness or timing has generally been based on calendar date. Beginning grazing based on a calendar date does not take into consideration plant development stage. Decisions based on calendar date may be right some years, but each year is different with respect to beginning of spring; thus, the calendar date method may not coincide with the best time to start grazing. Determining grazing readiness from the development stage of a few key grasses present on the pastureland or rangeland can serve as a guideline for management decisions.

The recommended plant development stage for beginning spring grazing of native and tame cool-season grass species is when the plants are vegetative and have formed 3 to 4 leaves. The events that are important for persistence and vigor in cool-season grasses occur about the time the fourth leaf forms a collar. These events include formation of leaves, tillers, rhizomes, stems, and heads. As the stem elongates at the 4-leaf stage the growing point is elevated and available for grazing. Grazing before stem elongation may result in a stem bearing head devoid of leaves. Grazing before initiation of tillers and rhizomes severely reduces dry matter production and causes weak and thinning grass stands.

The organs of a grass plant develop in an orderly and predictable manner. From a development stage perspective, a new leaf becomes visible on a plant after the one preceding it is almost fully developed. The formation of stems and heads, which contribute significantly to dry matter production, indicate the plant is in the reproductive stages of development. The calendar time at which the first leaf appears and the rate at which each leaf develops is determined by the amount of thermal (heat) energy accumulated during the growth period. The air temperature on any day differs from year to year; therefore, the amount of thermal energy available for plant development on any calendar date—hence development stage—also will vary from year to year.

Plant Development vs. Growth

Plant development and growth are processes that contribute to forage grazing readiness, but the two processes are not synonymous. Development refers to formation of plant parts, such as leaves, in an orderly and predictable pattern. Plant growth is the increase in dry weight resulting from the expansion of leaves, stems, and heads. Plant development stage is a phrase used to identify a specified stage of morphological development. There is a positive correlation between development and growth in forage grasses which suggests that grazing readiness can be determined from plant development stage based on the number of leaves formed. Initiating grazing at a specific development stage is predictable and can be repeated each year, whereas initiating grazing at a specific forage yield is not as easily predictable and may be highly variable.

Development Stage Scales

Describing the development stage of grasses can easily be accomplished by comparing plant morphology to development stage scales or schemes in the field (Fig. 1). There are scales available that were developed solely for scoring development stages in forage grasses and several that were developed for cereal crops that are also acceptable for use with forage grasses. The similarity in morphological structures between cereals and forage grasses allows for use of common scales for scoring development. Following is a brief description of selected scales that can be used to determine the development stage of perennial grasses. For details on each scale, the original reference citation should be reviewed.

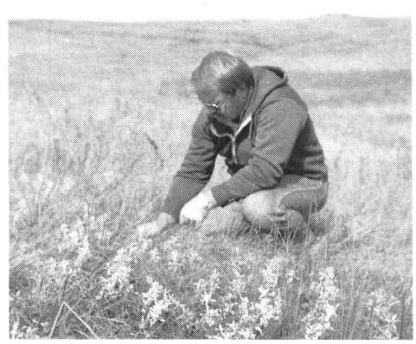

Fig. 1 *Scoring grasses for morphological development requires field visits.*

Haun

The Haun scale (1973), originally developed for wheat, is a numerical expression of plant morphological development based on the number of leaves produced on the main stem with additional descriptors for head development. The Haun scale has a high degree of precision in describing leaf insertion rate on the main stem. Plant development referenced to the Haun scale is highly correlated with growing degree-days (GDD), which provides utility for determining development stages through modeling. The Haun scale is simple, easy to use, and provides the basic information for making management decisions.

Moore

The Moore et al. (1991) scale was developed specifically for forage and range grasses. This scale utilizes a set of morphological descriptors for describing development of grass tillers through five primary development stages of germination, vegetative, elongation, reproduction, and seed ripening. Substages within each primary stage are used to provide sufficient detail to fully describe plant development. The numerical code describing the growth stage is easily memorized for field use and is acceptable for data entry and statistical analysis.

Sanderson

The Sanderson (1992) scale describes development of warm-season perennial forage grasses. It was developed for use with kleingrass and switchgrass, but is applicable to many other bunchgrasses. It is based on selected aspects of the Haun (1973), Simon and Park (1983), and Hedlund and Höglund (1983) scales. The scale describes 35 separate stages across development of the plant leaves, stems, and reproductive or head structures. The Sanderson scale is complex, providing detail and precision necessary for research applications.

Simon

The Simon and Park (1983) scale was developed for perennial forage grasses. This scale is based on the Zadoks et al. (1974) scale and like Zadoks uses a 2 digit code to describe the principal development stages for number of leaves, elongation of the sheath, stem elongation, inflorescence emergence, anthesis, and seed ripening. The Simon scale is very detailed and provides a complete description of all phases of plant development. The complexity of this scale makes it best suited for research purposes.

Zadoks

The Zadoks et al. (1974) scale was developed for cereal crops, but is applicable to all Gramineae. This scale has sufficient detail to describe all phases of plant development. This scale uses a 2-digit code. The first digit identifies the principal development stage and the second digit the secondary development stage. The Zadoks scale uses the ten principal development stages of germination, seedling growth, tillering, stem elongation, booting, inflorescence emergence, anthesis, milk development, dough development, and ripening to describe all phases of plant development. Secondary development stages are used to designate plant development within each of the ten principal development stages.

Use of Development Stage Information

Development stage information can be used in making management decisions on when to begin grazing initial spring growth and regrowth forage. In more intensively managed grass seed production applications, development staging information can be used to determine timing of herbicide and pesticide applications and harvesting operations. Development stage scales for determining grazing readiness need more detail during the vegetative leaf development period, whereas for seed production, the scales need additional detail from vegetative leaf production through seed ripening stages to be most useful for producers. In understanding plant development and in developing management criteria, it is important that scientists, action agency people, and producers use common terms in describing the development stages of forage crops. Accepting use of the development stage concept should provide a more detailed description of plant development events and be more effective for information transfer activities.

Air temperature is the main environmental factor that determines the rate of plant development.

Calculating Growing Degree-Days

Air temperature is the main environmental factor that determines the rate of plant development. Each leaf produced on a stem requires a specific amount of accumulated thermal energy, or heat units, for development. The temperature when plants initiate development or the base temperature is generally set at 32°F (0°C) for cool-season and about 50°F (10°C) for warm-season grasses. The temperature or accumulated heat units that a plant needs to produce a leaf can be expressed as growing degree-days or GDD. For any calendar day, the number of GDD for that day is the average of the daily hourly minimum and hourly maximum temperature in the same 24-hour period minus the base temperature. The equation for calculation is:

$$GDD = (Tmax + Tmin)/2 - Tbase$$

where GDD = growing degree days,
Tmax = daily maximum temperature,
Tmin = daily minimum temperature,
Tbase = 32°F for cool-season and 50°F for warm-season grasses

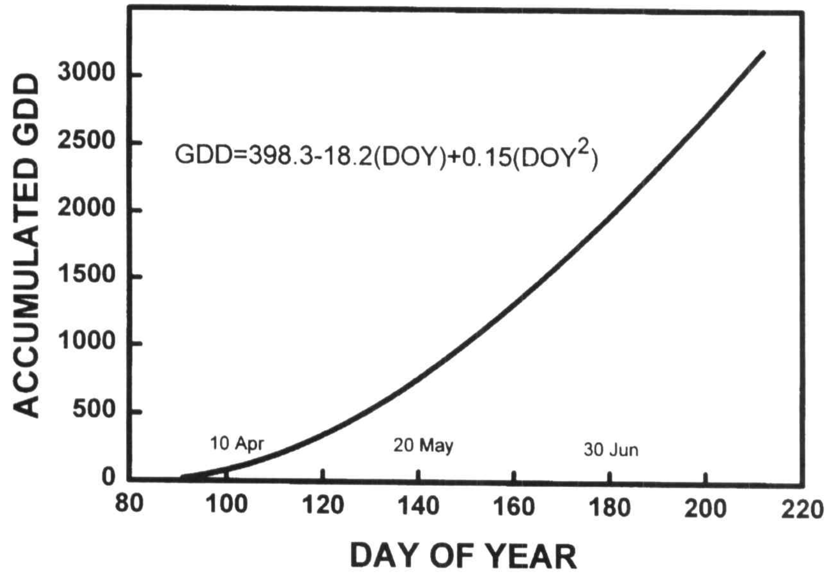

Fig. 2. *Accumulated growing degree-days calculated from the average daily minimum and maximum temperatures, using 32° F as the base temperature, for the 1951 to 1980 period at Bismarck, ND.*

Accumulating Growing Degree-Days

Daily Growing Degree Days (GDD) are summed to determine total GDD accumulated from initiation of spring growth to the current date. As an example, the average number of GDD accumulated at Bismarck, ND from April 1 to July 31 are presented in Fig. 2. The date in early spring to start recording temperatures for calculating GDD to determine development stage of perennial forage grasses is different than for annual forages or new seedings. In new seedings emergence dates are easily determined, but in established stands the time that growth and development begins in the spring is less obvious. Frank et al. (1985) determined that the optimum time to start recording accumulated GDD at Mandan, ND was on the first day after March 15 that the average daily air temperature (daily maximum + daily minimum/2) exceeded 32°F for 5 consecutive days.

Growing Degree-Days and Grazing Readiness

The recommended development stage for beginning grazing cool-season native and tame pasture grasses is the 3 to 4 leaf stage which coincides closely to Haun stage 3.5 (Fig. 3). The GDD needed to produce each leaf on some tame and native forage grasses as determined from regression analysis of accumulated GDD and growth stage using the Haun scale are shown in Table 1.

Native grasses generally require more GDD than improved grasses to produce a leaf (Frank and Hofmann, 1989; Frank and Ries, 1990). In order to use development stages for determining when to begin grazing, an indicator grass and the stage for beginning grazing should be determined. As an example, green needlegrass will be selected as the indicator grass at a Haun stage of 3.5. Data in Table 1 shows that green needlegrass requires 1209 GDD to reach Haun stage 3.5. It is best to calculate GDD from actual weather data as described earlier, but for this example the GDD and day of year relationship from Fig. 2 is adequate. To determine the date when 1209 GDD were accumulated at Bismarck, ND use either the equation or extrapolate from the regression line in Fig. 2. Either approach will show that by 6 June, 1209 GDD will have been accumulated. Therefore, from this example, using green needlegrass as the key grass on which to base our decision, grazing could start about 6 June. The date when using other native grasses as key grasses to reach Haun stage 3.5 would be needleandthread, 30 May; prairie junegrass, 20 May; and western wheatgrass, 1 June. Blue grama, a warm-season grass, reached Haun stage 3.5 on 30 June.

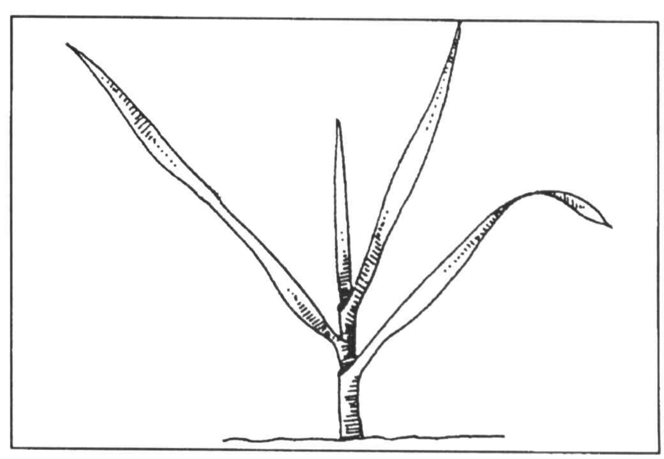

Fig. 3. *This grass plant has developed collars on three leaves. The fourth leaf is about one-half as long as the third leaf. The numerical score for scales listed in this paper for this grass plant would be Haun 3.5, Moore V3, Sanderson 3.5, Simon 23, and Zadoks 13.*

Table 1. Growing degree-days required for some native and improved grasses to develop to Haun stages 1 through 5.

	Native Range Grasses in Mixed Prairie				
	Haun Development Stage*				
Grass	1	2	3	3.5	4
Green Needlegrass	346	691	1037	1209	1382
Needleandthread	290	580	869	1014	1159
Prairie Junegrass	216	432	648	756	864
Western Wheatgrass	297	603	954	1170	1386
Blue Grama	423	711	1062	1296	1530
	Grass Seeded in Pure Stands				
Nordan Crested Wheatgrass	148	295	443	516	590
Intermediate Wheatgrass	225	450	675	787	900
Rodan Western Wheatgrass	178	356	535	624	713

*A Haun stage of 3.5 is defined as a plant that has 3 fully developed and collared leaves. The fourth leaf, when extended, would be one-half as long as the third leaf. This stage is about equivalent to the 3 leaf stage often recommended for beginning grazing of cool-season grasses.

The tame cool-season grasses require fewer GDD to form a leaf and can generally be grazed earlier than the native grasses or about the 3 leaf stage. Using Fig. 2 and following the same procedures as above, Nordan crested wheatgrass requires 443 GDD to reach Haun stage 3 which occurred on 6 May, intermediate wheatgrass needed 675 GDD (17 May), and seeded Rodan western wheatgrass needed 535 GDD (11 May). The differences observed between native prairie western wheatgrass and seeded Rodan western wheatgrass is due to selection by plant breeders for early development in Rodan.

Record Keeping

The Growing Degree Day (GDD) method requires the following record keeping to determine plant development stage. (1) Record the daily maximum and minimum temperatures and calculate the daily GDD. Temperatures can usually be obtained from weather reports on the local radio or television station or from newspapers. (2) Determine the starting date for calculating GDD which is the date that the grass begins to develop in the spring, not when the grass starts to turn green , but when the leaf blade begins to elongate. (3) Accumulate the GDD for each day from the starting date determined in step 2. If the daily maximum temperature is less than 32˚F for cool-season and 50˚F for warm-season grasses no GDD are accumulated for that day. (4) Use Table 1 to determine the GDD required for the key species listed to reach Haun stage 3.5. At this stage, these species would be ready for grazing. (5) It is also desirable that one visits the pasture weekly during the active growth period to become familiar with grass development and to verify calculated stages. By counting the number of leaves and determining the development stage, and by making comparisons to the GDD accumulated to that date, producers will better understand grass growth and development and can then make management decisions based on the plants growth condition.

Conclusions

Using the development staging and the GDD approach to determine grazing readiness will take the guess work out of when grazing can begin on rangeland and pastureland. If grazing is started at the proper development stage, the plants will be more tolerant of grazing stress and will maintain the higher vigor needed to continue forage production during the grazing season and in following years. Since the time of initiation of spring greenup determines the development stage of grasses and thus grazing readiness, the staging approach is more precise than the calendar date method for selecting the proper time to begin grazing.

Literature Cited

Frank, A. B., J. D. Berdahl, and R. E. Barker. 1985. Morphological development and water use in clonal lines of four forage grasses. Crop Sci. 25:339–344.

Frank, A. B., and L. Hofmann. 1989. Relationship among grazing management, growing degree-days, and morphological development for native grasses on the northern Great Plains. J. Range Manage. 42:199–202.

Frank, A. B., and R. E. Ries. 1990. Effect of soil water and nitrogen on morphological development of crested and western wheatgrass. J. Range Manage. 43:255–258.

Haun, J. R. 1973. Visual quantification of wheat development. Agron. J. 65:116–119.

Hedlund, E. K., and S. Höglund. 1983. Scheme of development in timothy, red clover, and lucerne. Unpublished M.S. Thesis. The Royal Swedish Agricultural College, Uppsala, Sweden.

Moore, K. J., L. E. Moser, K. P. Vogel, S. S. Waller, B. E. Johnson, and J. F. Pedersen. 1991. Describing and quantifying growth stages of perennial forage grasses. Agron. J. 83:1073–1077.

Sanderson, Matt A. 1992. Morphological development of switchgrass and kleingrass. Agron. J. 84:415–419.

Simon, U., and B. H. Park. 1983. A descriptive scheme for stages of development in perennial forage grasses. p. 416-418. *In*: J. Allan Smith and Virgil W. Hays (eds.) Proc. XIV Int. Grassl. Congr. Westview Press, Boulder, Colo.

Zadoks, J. C., T. T. Chang, and C. F. Konzak. 1974. A decimal code for the growth stages of cereals. Weed Res. 14:415–421.

The author is with the USDA, Agricultural Research Service, Northern Great Plains Research Laboratory, P.O. Box 459, Mandan, North Dakota 58554.