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Planning for Plant Growth using the Grazing Response Index

Sherman Swanson, University of Nevada, Reno Extension,
Dave Voth Nevada Department of Agriculture, and
Juan-Carlos Cervantes, University of Nevada, Reno Extension

As cold moist soils warm up, plants grow leaves with stored carbohydrates. The leaves produce food for the plant by using photosynthesis to grow more leaves, stems, roots and seeds. Plant growth makes forage, and plants store excess food (e.g. carbohydrates and protein) to make next year's forage. Depending on management strategies, grazing (or browsing) can slow or enhance plant growth. Grazing can enhance plant growth by allowing growing leaves to gain access to sunlight or by recycling nutrients, but during the growing season, grazing removes leaves that were capturing energy. Not grazing allows leaves to continue growing, producing forage up to a point. However, forage for animal production is of the highest quality while plants are green and growing. Therein lies a principal challenge for grazing management. Using the different plant communities across a ranch, many producers strive to have livestock graze green forage while it is at its most nutritious value for as long as possible, especially when livestock nutritional needs for production and reproduction are greatest. To grow useful forage plants rather than useless weeds, producers manage the timing, duration, and intensity of grazing, and the timing and duration of recovery periods. Grazing management requires a strategy and planning.

The Grazing Response Index

The grazing response index was created by people teaching the Colorado Range Management School (Reed et al. 1999). It combines several components of a grazing strategy: frequency of defoliation (bites per grazing season or before complete recovery), intensity of use (growing season utilization), and opportunity for growth or regrowth (while not being grazed). The Nevada Rangeland Monitoring Handbook, Ranchers' Monitoring Guide and other publications highlight the utility of the index as a grazing management planning tool (Swanson et al. 2018; Perryman et al. 2006; Wyman et al. 2006). The index can be used after the grazing or growing season to help interpret multiple data sources, such as actual use records, notes about utilization or residual vegetation, and the time of the growing season (phenological stage) when grazing occurred. All these factors influence growth this year and next year. Before each grazing season, the index can be used as a planning tool.

The index score varies from -4 to +4 and is calculated using the following components:

Frequency — The number of times a preferred plant is bitten during active growth, based on duration of grazing during a growing period divided by seven or up to 10 days.

- Once (or none) = +1
- Twice = 0
- Three or more bites = -1

Intensity — Utilization or leaf material remaining for growth at end of growing season grazing.

- Light , more than 60 percent remaining = +1
- Moderate 45-59 percent remaining = 0
- Heavy less than 44 percent of leaf remaining = -1

Opportunity — Portion of the growing season available for growth or regrowth.

- Full season = +2
- Most = +1
- Some chance = 0
- Little chance = -1
- No chance = -2

Total provides a positive, neutral or negative rating of grazing impacts for the year.

Frequency of defoliation

When a growing plant is grazed, the part of the plant removed can no longer capture sunlight energy. Other leaves continue photosynthesis, and with enough leaf area, time and soil moisture remaining in the growing season, plants can regrow. However, there may be a delay if the

growing point where cells divide was removed by grazing. The rate of regrowth varies by season, soil moisture plant species, and temperature. If the grazing animals remain in the area after regrowth, the fresh leaves are often grazed off again. After seven to 10 days, regrowth of grazed plants is often preferred because these plants are the preferred species or in a preferred location (the reason they were first grazed), and because fresh growth is more nutritious than older leaves with more lignin or other anti-quality compounds. Season-long light stocking is often hard on the best forage plants (graze the best and fertilize the rest). Ungrazed plants may become "wolfy" with old leaves and thatch that deters grazing. Ungrazed neighboring plants (e.g. weeds) may outcompete forage plants. Overgrazing or repeated use before full recovery happens to the most palatable and preferred plants first and on an individual basis. On the grazed plants, the second bite again diverts growth away from roots, and the preferred forage plants may fall behind in the competition to grow and occupy soil. The more often preferred plants are bitten without adequate time
for full recovery, the more they are stressed, and the less they can grow, reproduce and store carbohydrates for next growing season.

To evaluate the frequency of bites, the duration of grazing during the growing season is divided by the time needed for sufficient plant growth to stimulate re-grazing.

Plant growth in cold deserts is slow when soils are cold. As soil warms and leaves provide more food for leaf growth, growth rate increases (Figure 1). Growth rate decreases as soil moisture decreases, the weather gets too hot or too cold, and as plants switch from growing leaves to growing seeds or storing food for next year. For simplicity in using the index, the growth curve is divided into three phases, slow growth, fast growth, and slow growth. To estimate the number of bites on the preferred forage plants, the number of grazing days during slow growth is divided by up to 10, and the number of fast growth grazing days is divided by seven. This time period may vary where local observations of use on key species support a different time period for plant regrowth and repeated grazing.

Because all plants can be grazed and thrive when grazing periods allow time for only one bite, this duration is scored as a plus one (+1) for frequency. Time for two bites (with one on regrowth) is scored at zero (0), and time for three or more bites is scored at minus one (-1).

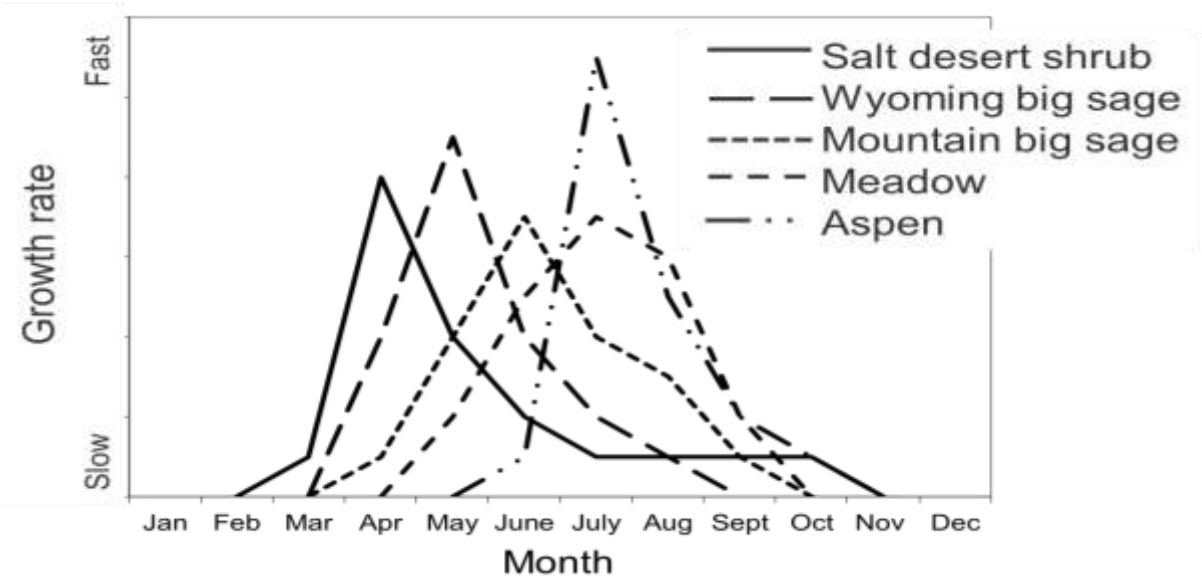

Figure 1. These growth curves estimated by Brad Schultz, Humboldt County Extension Educator, show that different plant communities on a ranch grow at different times depending on soil temperature and moisture. The growing season for each plant community could be divided into periods of slow and fast growth and these vary by year depending on weather.

Intensity of defoliation - As discussed above, plants use leaves to grow roots, stems, leaves, seeds, etc., and to store carbohydrates to grow next year. Excess removal of leaf material has long been a focus of rangeland managers with measurements of utilization rate or stubble height remaining to adjust animal unit months (e.g. cow AUMs). Managing for proper utilization and not overgrazing has been a dominant theme of public lands management in Nevada as exemplified by the first Nevada Rangeland Monitoring Handbook (Nevada Range Studies Task Group 1984). However, it is often assumed that the utilization should be measured at the end of the growing and grazing seasons to reflect all grazing as offset by regrowth. The index is about plant growth, so the focus is on the growing season. Utilization on dead or dormant herbaceous plants makes much less impact than grazing photosynthetically active leaves.

To evaluate the intensity of grazing, consider the proportion of leaf area the forage plants had during or at the end of their growing season; or, at the end of the grazing period if animals left or were moved during the growing season. Plants with most of their leaves available for growth at this time could still grow at a normal rate, so these areas are scored plus one (+1), with more than 60 percent of their leaf area remaining or less than 40 percent utilization. Pastures or use areas with forage plants with moderate utilization (41% to 55 percent utilized) and 45 to 59 percent or more of their leaf area still photosynthesizing are scored at zero (0) because they can easily recover from such an impact. Where plants were grazed more heavily (more than 56 percent) will likely decline in root and plant growth if this growing season intensity continued over several years. These areas are scored at minus one (-1) due to the lack of plant leaves for photosynthesis.

Opportunity to grow or regrow - Rangeland plants can recover from previous years grazing or from grazing earlier in this growing season if provided the opportunity to grow leaves and then use leaves to produce carbohydrates needed for more growth. This recovery can only happen during the growing season. The portion of the growing season when preferred forage plants are not being grazed is the key to success in many grazing management strategies. Grazing during the dormant season has little or no physiological effect on the dead leaves or dormant root crowns of herbaceous plants such as grass.

To evaluate opportunity to grow or regrow, consider the portion of the growing season when livestock are not present and when plants can be growing and/or recovering. If grazing occurs only during the dormant season and forage plants were rested during the growing season, score the management/area at plus two (+2). If grazing occurs only during a small fraction of the growing season and most of it is available for growth or regrowth, score a plus one (+1). If grazing occurs during more of the growing season, but there is some chance for growth or regrowth, score opportunity at zero (0). If there is little chance for preferred forage plants to grow or regrow because grazing overlaps most of the growing season, score opportunity at minus one (-1). If grazing is growing-season-long, score opportunity at minus two (-2).

Total GRI score - For a given year, the index score is the total of three components of grazing influences on plant growth and recovery from grazing (frequency, intensity and opportunity). The total score can vary from plus four to minus four. This index indicates the likely impact of grazing on preferred forage plants. Index scoring can provide confidence that grazing management was within the ability of rangeland forage plants to recover from grazing and maintain their health. Conversely, it can suggest that preferred plants may be stressed. Because rangelands vary in the physiological and ecological resilience and resistance to grazing and other management impacts, the grazing response index is not a guarantee of success or of failure. Rather, it provides a planning tool for evaluating the anticipated effects of management, past or future. When combined with other monitoring information, such as precipitation and long-term or effectiveness monitoring records, the index can help interpret past management and adapt management to accomplish different results.

Planning for plant growth and a positive GRI - Scores can help livestock and rangeland managers succeed in the ongoing process of adaptive management by helping them to:

1. recognize places where management may have stressed plants (negative index score);

2. appreciate management likely to be successful, indicated with a positive index score each year or an average positive score across years;
3. plan management strategies (season and duration of use and non-use) for a positive score;
4. consider management adjustments and waters or fences that could improve the score; and
5. evaluate success over a period of years, especially where long-term or effectiveness monitoring suggests progress toward meeting resource objectives, or not.

For example, low frequency scores can be improved with either shortened periods of use or by shifting the period of use to a slower growing or dormant season. Either of these adjustments also enhances the opportunity score. Grazing with one larger herd, rather than two smaller herds uses the animal unit months (AUMs) of forage in less time (higher frequency and opportunity scores) and usually does not change the intensity score. Another way to increase stock density in any one area and shorten the duration (number of bites) is to divide the pasture into multiple use areas grazed one after the other.

More use areas - Frequent, managed, and intentional animal movement within a pasture can create shorter use periods and longer recovery periods. Animals that move frequently and as a herd, are leaving a use area within a pasture with plenty of recovery time use areas within a pasture will earn higher index scores than if the whole pasture is scored together as one use area (Swanson and Voth 2019a). Separate use areas may also lower utilization (higher intensity score) in areas that had been grazed too heavily or at the wrong time. The separate use areas may address distribution to avoid intense use in some areas. To create more growing season use areas, consider these options:

1. cross fence with permanent fencing or temporary electric fencing;
2. develop new water or control water availability with a shut-off valve or fencing with gates around the water;
3. use protein supplement to attract livestock away from riparian areas when upland forage becomes dormant;
4. apply stockmanship to place livestock (often more successful with protein supplement);
5. graze big pastures in a big circle with a moving herd;
6. graze earlier in spring when cattle will follow the green up the mountain;
7. use multiple species in a pasture (e.g. sheep may use steeper rangeland and more forbs and shrubs than cattle);
8. graze in a different season when livestock will go to different places because of forage or water availability;
9. graze small fenced pastures in summer and dormant rangeland in fall and winter, with emergency haystack for rare deep snow years; and
10. graze twice, once in the growing season – quickly across all or many pastures, and once after the growing season (Swanson and Voth 2019c)

Water - A larger herd using a use area in a shorter time requires a water source large enough to water the herd, even if livestock do not consume more water. Substantial areas in Nevada have only limited amounts of water developed, and this has led to long seasons of use with a smaller herd. Where the water is flowing from a riparian area, a long season of use can impair the ability of the riparian area to store water, and this further limits herd size or controls the season and duration of use. Water developments that tap riparian areas and do not have and use proper shut of valves and/or float valves also drain and shrink the riparian area and decrease aquifer storage. To restore riparian functions and rangeland plants, it is much better to consider index-score-increasing options, such as larger herds for a shorter time and properly plumbing and managing larger water developments with adequate storage. Many options for water storage are available, but often the best is a properly functioning riparian area storing water underground from precipitation or snow-melt events with aquifer recharge.

Range readiness - With season-long grazing, waiting for range readiness in the spring allows plants to grow before grazing. Animals are then less likely to get ahead of the forage and keep it from growing. Unfortunately, this strategy had only limited success, and it also often worsened conditions in riparian areas. Without movement of livestock, important parts

of many pastures suffered from repeated growing-season grazing with little or no recovery. To avoid overgrazing, livestock numbers have been reduced in many areas. Many of these areas may have been under-stocked, leaving wolfy plants or converting to more shrubs and then more cheatgrass, while the preferred forage plants were over-grazed. Managing for plant health with the insights provided by the index provides alternatives for plant health and enables targeted grazing for desired results.

The index focuses on the growing season. Index-inspired strategies enable grazing when forage is most nutritious and keeps plants healthy. Optimal livestock production keeps livestock consuming green forage for as much of the year as possible, and matches the biological cycle of the cow to the forage nutrition cycle of the range. To accomplish this, keep animals moving while plants grow. Movement of the herd considering the growing seasons of rangeland plant communities optimizes animal nutrition, the index score and plant growth. Grazing in the dormant season lowers the nutrition of the forage at the time of consumption, but may provide an economical alternative to feeding hay. Furthermore, dormant-season grazing causes little stress and some benefits to rangelands and plants.

Wildlife and wild or feral horses or burros - While the management tools discussed above are most applicable to livestock, other herbivores consume forage and may create the bulk of the grazing impact in certain locations. Typically these populations are only managed through adjustment of herd or population size. Some herds migrate, using different community types or parts of a rangeland in different seasons. Where use by these animals is significant, their use can also be included in the index scoring or thought process by specifically noting their intensity and actual use dates in relation to growing season.

Index scoring has been used to evaluate wild horse impacts to riparian areas. Season-long use with little growing season time for recovery suggests causal factors for riparian losses and impaired functions (McCue 2019). Stocking rate is a weak tool for fixing issues with riparian grazing management of cattle (Swanson et al. 2015). Riparian pastures were suggested for important sage-grouse late brood rearing habitats by the Nevada Sage-grouse Conservation Plan (Nevada Sagebrush Ecosystem Technical Team 2014). This suggest that appropriate management levels may need to be reduced and herds more tightly managed to "achieve and maintain a thriving natural ecological balance on the public lands," protect wildlife habitat, and prevent range deterioration (Wild Free-Roaming Horses and Burros Act of 1971 (16 USC § 1332 (f))).

Mixing it up - Animals go to different places in a pasture depending on the season of use. They also eat different plants and plant parts. Plants grow different plant parts or emphasize different physiological processes at different timesthe growing season. So, mixing up the season of use among years in each pasture or use area helps the diversity of plants across a pasture to thrive.

The index could easily be augmented with an additional planning tool to evaluate variation in use period between or among years (Swanson et al. 2015). Also, principles appreciated through the index could be used to describe strategies (Swanson 2019b) for grazing management that could then guide implementation or short-term monitoring. These strategies for management should support plant growth and be designed to reach objectives.

Conclusion - Adaptive management relies on a combination of short-term or implementation monitoring focused on management strategies and long-term or effectiveness monitoring focused on attainment of resource objectives. The grazing response index can be a powerful planning tool for adaptive management Swanson et al. 2018). The index is most useful for thinking about grazing management strategies and how they likely affect plant growth and plant health in various locations across a ranch or pasture. Impacts can be managed by adjusting or changing the period of use, duration of use, timing and duration of recovery or rest periods, and stocking rate. These adjustments interact and should vary among years. Challenges in implementing useful changes may stem from a lack of appropriate infrastructure, such as water sufficient for the larger herd, or from failure to consider tools that are available and could enable positive change. Often the conversation needed to enable change requires reframing of the issue from avoiding over-grazing to grazing for plant health. To effect this, it is useful to producers and rangeland management specialists to score and discuss the index together.

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