THE UNIVERSITY OF ARIZONA
Cooperative Extension

az2156 August 2025

The Modified Grazing Response Index – an improved planning tool for rotational grazing of livestock

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Figure 1. Cattle grazing at the Santa Rita Experimental Range (SRER) in Southern Arizona. Photo Credit: Andrew Antaya

Introduction and History

The Grazing Response Index (GRI) is a simple and effective grazing evaluation tool that was initially developed at Colorado State University by Floyd Reed, Roy Roath, and David Bradford in 1999. The goal of the GRI is to rapidly assess the effects of grazing and provide data to aid in the development of grazing plans for the following year. To effectively use this tool an understanding of plant physiology and plant responses to grazing is necessary. The GRI has allowed range managers to evaluate multiple complex factors related to grazing in a timely manner to assist in conversations leading to meaningful management decisions. The ability to easily communicate and comprehend the outcomes of the GRI has become a significant feature highly valued by range managers, environmentalists, and grazing permittees (Reed et al., 1999). The general intention of the GRI is to provide feedback on management decisions while minimizing time and resource commitments. The GRI does not replace other rangeland monitoring and inventory methods, and it is not recommended to rely solely on the GRI alone in cases where there are significant resource conflicts or concerns, as these situations are often complex and require detailed, comprehensive monitoring to accurately assess changes in range condition and detect long-term trends. The GRI relies primarily on observational data and minimal measurements, which limits its ability to identify subtle ecological changes that can have major impacts over time. However, it is useful as a supplemental tool alongside established long-term monitoring methods for serious resource issues and may provide an early indicator of potential resource management concerns during the interval between long-term monitoring data collection and analysis. The primary purpose of the GRI is to provide a simple and straightforward way to assess the effects of year-to-year planned grazing and to assist managers in developing grazing plans for the following year.

While the GRI has proven to be simple and effective grazing assessment tool, updates to its basic framework are needed to reflect recent scientific findings and broaden its applicability in grazing regions where year-round grazing is typical. One notable limitation of the GRI is that it does not account for dormant season grazing, which is common in many southwestern rangelands systems where winters are milder. As a result, we propose the Modified Grazing Response Index (MGRI), an updated version of the GRI, tailored to the needs of the southwestern United States and other areas that may have year-round grazing.

Areas that allow year-round grazing are largely dominated by warm season grasses and have mild winters. For that reason, the MGRI accounts for the availability of dormant season grazing during winter months. To broaden usability and accommodate areas that contain both warm-season and cool-season grass species, we recommend using a separate scoring sheet for each growing season. This will require adjusting the growing and dormant seasons for each growth type accordingly when scoring the MGRI. By using separate scoring sheets, producers and land managers can adjust their management practices to the specific needs of each growth type. Although these changes may slightly increase the overall complexity and time commitment required for the MGRI's use, they are also likely to facilitate more informed management decisions and foster productive conversations between land managers and grazing permittees.

GRI Overview

The original GRI uses three concepts to assess the effects of grazing: Frequency, the number of times forage plants are defoliated during a grazing period; Intensity, the amount of leaf material that is removed during a grazing period; and Opportunity, the amount of time plants have to grow prior to grazing or to regrow after grazing has taken place. These concepts were selected because they are all linked to mechanisms that control plant responses to grazing. As stated earlier, an understanding of plant physiology and plant responses to grazing is necessary for proper use of the tool (Reed et al., 1999).

To score Frequency, divide the number of days in the grazing period by 7, or up to 10 if growth is slower. To score Intensity, describe the amount of leaf material removed during a grazing period using light (<40%), moderate (41-55%), or heavy (>56%). To score Opportunity, assign scores based on the appearance of vegetation at the end of the growing season. For example, if the plants had full opportunity for growth before the grazing period assign a value of +2. If the plants look like they were used but regrew well assign a value of +1. If the area has the appearance of being heavily used, with no regrowth, assign a value of -2 (Reed et al., 1999).

Once all three concepts; Frequency, Intensity, and Opportunity are scored, a total score is assigned to each grazing area (e.g., pasture or allotment) based on the summation of the score for each concept. The scores can result in a positive, neutral, or negative value. A positive value indicates management is beneficial, a neutral score indicates management is neutral, and a negative value indicates management may be harmful to rangeland plant health (Reed et al., 1999).

Adjustments In the MGRI

Frequency

The frequency of defoliation can be a major factor influencing a plant's overall health and long-term productivity. Three or more successive defoliations of an individual plant in one growing season is detrimental to the plant. If continued for multiple consecutive growing seasons, successive defoliations will reduce a plant's productivity and/or ability to remain a viable part of the plant community (Ellison, 1960). Frequent defoliation events often lead to high-quality and palatable plants being grazed multiple times during the growing season, which over time can reduce overall community productivity and diversity (Steffens et al., 2013). While it is crucial to avoid three defoliation events, it is also advisable to refrain from a second defoliation during sensitive growth stages in a plant's life cycle. Avoiding a second defoliation of perennial grasses during the growing season offers substantial benefits in preserving the quality of available forage resources for future use and allows enough biomass to remain for the following winter dormant season (Noelle et al., 2020).

The challenge in avoiding a second defoliation is that it is difficult to predict exactly when a second defoliation will occur due to defoliation rates being significantly related to stocking density. In Noelle et al. (2020), 8% of plants were defoliated twice by day 15. Briske & Stuth (1982) found that under a moderate grazing regime, the second defoliation first occurred on day 14, and the first instance of a third defoliation occurred on day 18. Wade and Carvalho (2000) reported defoliation intervals ranging from 14 to 21 days in their research. A large-scale study, which sampled 4,566 plants across 300 different plots between June and July, showed a 16.6% chance of regrazing occurring during this time period. The second defoliation occurred first on day 8, with 90% of regrazing taking place after day 14 in a continuous grazing system (Norton & Johnson, 1986). These studies highlight the significant variability in defoliation frequency but generally suggest that a second defoliation tends to happen around day 14 or day 15.

The original GRI proposes the option of dividing the number of days grazed by 7 or 10 (see Table 1), which is based on the time required for necessary regrowth to sustain regrazing. However, this time frame can be species specific and influenced by a wide range of environmental conditions (Briske & Richards, 1995). We find the research

Table 1. Scoring Tables Comparison for Grazing Response Index (GRI) Frequency and Modified Grazing Response Index (MGRI) Frequency. The MGRI Frequency Table is to be Used Only During Growing Seasons.

GRI Frequency		MGRI Frequency	
Number of Defoliations	Value	Number of Defoliations	Value
One (or zero)	+1	One or zero, 0-15 days	+2
Two	0	Two, 16-30 days	0
Three (or more)	-1	Three, 31+ days	-2

above supports dividing the number of grazing days by 15, as this better reflects the probability of a second defoliation occurring, rather than focusing on the plant's specific regrowth needs which can vary. To score this portion of the MGRI, divide the number of grazing days during the growing season by 15 to calculate the number of defoliation events (see Table 1). For example, if a pasture was grazed for 21 days, you would divide 21 by 15 equaling 1.4. Since the score has exceeded 1.0, it means a second defoliation has likely occurred giving you a Frequency score of 0. The values of this portion of the MGRI have been increased by one, with values of (-2) for three defoliation events, (0) for two defoliation events, and (+2) for a single or zero defoliation events.

Most of the supporting research suggests avoiding frequent defoliation during the growing season. Therefore, we recommend Table 1 of the MGRI, be scored only during growing seasons. When grazing outside of growing seasons, there is no recommended grazing duration and the Frequency portion of the MGRI is not scored. However, it is recommended to stock pastures to not exceed a utilization level of 40-60% (Davies et al., 2016). Local range staff and permittees should work together to determine the start and end of the growing and dormant seasons and adjust these dates for each location each year due to variations in precipitation patterns.

Intensity

While the original GRI scored Intensity based on the descriptive amount of leaf material removed and not by utilization, we believe it is more objective to score this portion of the MGRI using utilization estimates (see Table 2). This allows the relation of MGRI data to utilization monitoring and provides more accurate measurements of forage removal. Utilization estimates are already widely used for adjusting stocking rates, identification of distribution patterns, and measuring grazing pressure on vegetation.

To better accommodate the ease of use with the MGRI we have assigned utilization values to closely align with those used in the Landscape Appearance Method, an ocular estimation technique that categorizes forage utilization into a range or class based on general appearance rather than precise measurements (Smith et al., 2012). This approach was chosen as the Landscape Appearance Method is a common utilization monitoring method. This should provide a smooth transition from the utilization data that is collected regularly to the MGRI Intensity category. This adjustment greatly expands the utilization ranges from the original GRI, as shown in Table 2, which results in this component of the MGRI having greater weight in the overall score. To score Table 2 of the MGRI, place your utilization value into the utilization class that it falls on or between.

Table 2. Scoring Tables Comparison for Grazing Response Index (GRI) Intensity and Modified Grazing Response Index (MGRI) Intensity

GRI Intensity		MGRI Intensity	
Level of Defoliation	Value	Utilization Class	Value
Light <40%	+1	0-5%	+3
Moderate 41-55%	0	6-20%	+2
Heavy >56%	-1	21-39%	+1
		40-50%	0
		51-60%	-1
		61-80%	-2
		81-100%	-3

Opportunity (Grow or Regrow)

If a grass plant has a majority of its leaf surface removed frequently without adequate time to regrow, the plant's production is significantly reduced due to an insufficient energy supply (Stichler, 2002). The recovery phase must take place during the growing season for adequate regrowth of leaves to occur. This allows the plant to produce the necessary amount of carbohydrates needed for regrowth following grazing events, supporting the plant's overall health (Swanson et al., 2015).

This section of the MGRI (see Table 3), has been expanded to provide more precise time frames for regrowth durations. Percent ranges for rest intervals were included instead of judgement-based observations to offer clearer guidelines on the duration of these periods. This adjustment aims to establish more standardized usage across various environments when using the opportunity component of the MGRI. This is one section of the MGRI that will need growing season dates to be clearly defined each year as growth times for cool-season grasses and warm-season grasses can vary. To score Table 3 of the index, first determine the length of your growing season in days. Then calculate the number of days the area remained ungrazed and determine what percentage that represents of the total growing season.

Table 3. Scoring Tables Comparison for Grazing Response Index (GRI) Opportunity and Modified Grazing Response Index (MGRI) Opportunity

GRI Opportunity		**MGRI Opportunity**	
Opportunity to Grow or Regrow	Value	Opportunity to Grow or Regrow	Value
Full season	+2	Full Growing Season	+3
Most of season	+1	Most (60-99% of growing season)	+1
Some chance	0	Some (30-59% of growing season)	0
Little chance	-1	Little (1-29% of growing season)	-1
No chance (Continuous)	-2	None (Continuous use during growing season)	-3

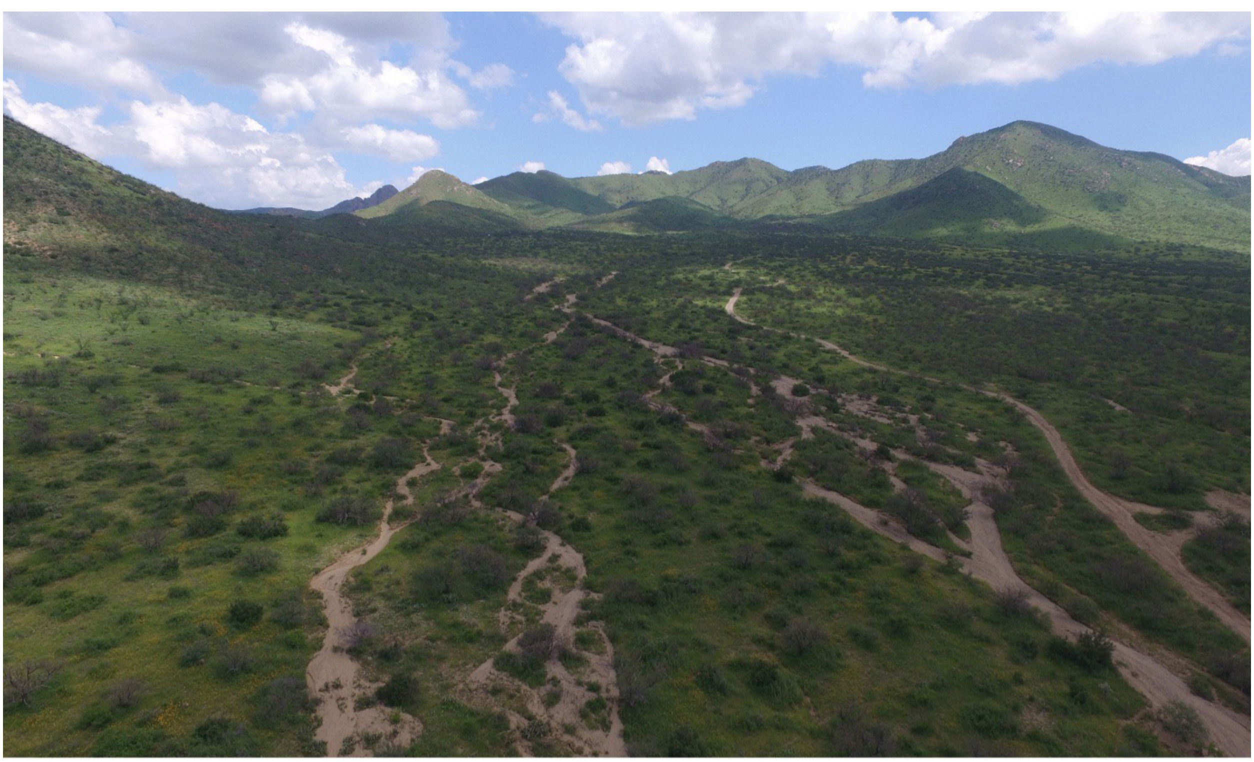

Figure 2. Landscape photo of the Santa Rita Experimental Range (SRER) post-monsoon season. Photo Credit: Andrew Antaya

Additions

Timing

While the three core elements of the GRI; Frequency, Intensity, and Opportunity were adjusted, we felt it was necessary to include a fourth factor in the MGRI, Timing. We felt the Opportunity section of the original GRI did not sufficiently address the negative impacts that can arise from grazing the same location, year after year for consecutive years. Severe repeated defoliation of plants can lead to weakened root systems which can lead to reduced drought tolerance. This can affect a plant's ability to survive in arid environments. By including an additional section for Timing of grazing, we emphasize the importance of altering grazing times based on the phenological stages of the dominant plant groups (i.e. dormant or growing). Alternating grazing periods allow plants to complete important growth stages (vegetative, boot, seed production, and dormancy) while maintaining their vigor, leading to better rangeland health (Schroeder & Johnson, 2019; Swanson et al., 2015; Mullahey et al., 1990).

While grazing during the growing season can lead to negative effects, grazing during the dormant season may be less harmful or beneficial. A plant's dormant phase is the least critical period for forage removal because plants are photosynthetically inactive (Holechek et al., 1998). Grazing during a dormant season can result in benefits such as reducing invasive and exotic annual plant species presence and an increase in native perennial bunchgrass production (Davies et al., 2021; Schmelzer et al., 2014; Vermeire et al., 2023; Waterman & Vermeire, 2021). Grazing specifically during a winter dormant season has been shown to reduce herbaceous fuel cover, continuity, height and biomass (Davies et al., 2015). However, it is still recommended to not overstock your grazing area during the dormant season as heavy use during this time can lead to increases in bare ground, decreases in total standing crop, reduced infiltration rates and increased sediment loss for soils (Vermeire et al., 2023; Warren et al. 1986). Grazing too close to the crown can also be detrimental, as removal of basal growth can expose the plants, not leaving them enough stubble for protection from extreme temperatures during the winter season (Schroeder & Johnson, 2019).

In Table 4, we have assigned a value of (-2) to grazing occurring during growing seasons. Conversely, we have assigned a positive value of (+2) to grazing during dormant seasons which is typically during the winter, and a value of (0) to grazing during partially dormant seasons which is usually during the spring or summer months. During spring or summer months, plants may enter dehydration avoidance or dehydration tolerance, which is essentially a form of partial dormancy if they do not enter obligate dormancy (Gillespie & Volaire, 2017). The concern is that if favorable conditions occur, plants may initiate regrowth, making them susceptible to grazing during a period of growth. Summer/spring grazing is also a shorter grazing period in most arid regions where the environmental conditions and forage quality limit the amount of time animals are actively grazing (Larson-Praplan et al., 2015). Given the variability of these processes and the significant impact of environmental factors, we have assigned a neutral score. We have assigned low values to this section of the MGRI as we feel it is an important factor to consider but did not want to weigh it heavily enough to change the core focus of the original GRI (see Table 4).

To score Table 4 of the index, define the dates for your dormant, partially dormant, and growing seasons. Next, place your grazing dates within these timing periods and use the value assigned to each period. If the grazing dates overlap into different timing periods, default to the lower score. It is important to adjust these dates for your specific region as growing, partially dormant, and dormant seasons are likely to vary between regions.

Timing – Takes into account two factors: the time of year a grazing location is used by livestock and the phenological stage of the plants found in the grazing location.

Table 4. Scoring Table for Modified Grazing Response Index (MGRI) Timing

MGRI Timing	
Season of Use	Value
Dormant Season	+2
Partially Dormant Season	0
Growing Season	-2

Conclusion

The MGRI retains its core as a simple tool to evaluate the effects of grazing and current management practices. It plays a valuable role in the planning process by providing more information on how often grazing occurs, how much forage is being used, and the specific times of year grazing occurs or does not occur. By identifying grazing patterns and periods of rest, it can assist ranchers and range managers to plan grazing rotations, maintain adequate use, and optimize forage recovery, leading to more productive land management.

The additions and changes account for year-round grazing activity and plant communities that are largely dominated by warm-season forage. These modifications are intended to make the MGRI a useful tool for understanding the impacts of management decisions in regions where year-round grazing is typical. The MGRI aligns itself with standardized practices commonly used by public land managers and rangeland practitioners, enhancing its usability across various grazing regions.

The MGRI is designed to remain practical and should not require additional fieldwork, maintaining its value as a straightforward and practical planning tool for rangeland managers. Most grazing locations already have the data needed for the MGRI tool to work effectively if management records are available and regular monitoring is conducted. It's ability to assess the possible effects of grazing management decisions while still considering recent, current, and planned grazing rotations will support better informed management decisions, as well as productive conversations between grazing permittees and rangeland managers.

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