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Foraging Behavior and Grazing Management Planning

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A successful grazing management plan requires a sound understanding of the effect the grazing animal exerts on the range or pasture ecosystem. The grazing animal exerts pressure on the range or pasture ecosystem through consumption and trampling of the plants, by their digestive processes, and by their movement across the landscape. Separation of this total influence into individual factors (Heady and Child 1994) increases understanding of the grazing impacts and promotes informed grazing management decisions. Managers who learn to manipulate the grazing factors listed in Figure 1 are typically the most successful at maintaining forage and animal production goals.

The goals and objectives of a successful range or pasture management plan are achieved only through two distinct methods of manipulation of the vegetative community: (1) by altering the grazing factors or (2) through range improvement practices. Range improvement practices include applications of seeds, fertilizers, or other improvements directly to the soil-vegetation complex. While these practices can be an important and effective tool for land managers, they are usually costly. For this reason they are usually reserved for drastically disturbed rangelands and pasturelands, where recovery from degradation would otherwise be too slow.

Four grazing factors

A grazing animal *selects* for certain plants or plant parts and consumes them to a particular degree, resulting in a certain grazing *intensity*. This grazing event occurs during a specific *season* in the growth of the plant and may be *repeated*. Each of these four factors—selectivity, intensity, season, and frequency (repeated grazing)—influences the growth and reproduction of the grazed plants differently. Inherently then, plant communities are influenced differently. Thus management of the animals can influence the vegetation of range and pasture systems by manipulating their relationship to the four grazing factors (Figure 1).

It is important to understand, however, that one grazing factor does not occur without the others. Grazing animals exert the various grazing impacts at the same time (Figure 2). For example, a cow tramples plants while grazing forages to a definite degree or intensity during a specific season (or period of growth for the plant). Thus, the grazing process and the resulting plant response is a dynamic interaction dependent on the composition of the plant community and the species of animal (which determines animal behavior).

Successful livestock managers generally have a good understanding of the dynamics of interaction between grazing animals and the plants that support them. While the response of the plant community to grazing is important to a grazing management plan, it is not the focus of this publication. Instead, we provide an overview of the factors that influence foraging behavior and show how it needs to be considered in the development of a successful grazing management plan.

Foraging behavior

Different kinds (species) and classes (heifer, steer, lactating, growing, etc.) of grazing animals utilize range

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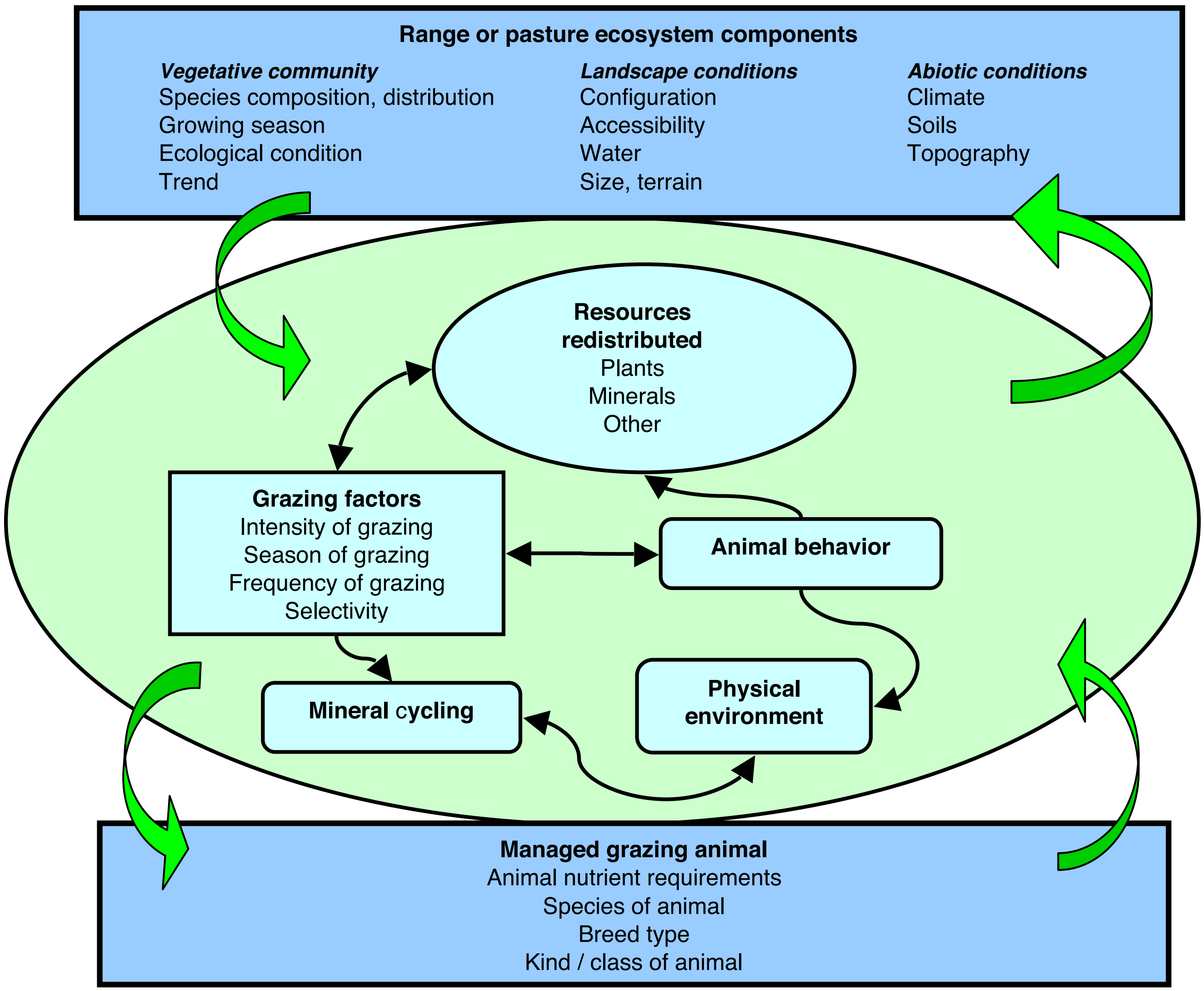

Figure 1. A conceptual representation of the relationship between the land, animals, and vegetation (adapted from Heady and Child 1994).

and pasture systems differently (Figure 3). Specifically, the foraging behavior of a given kind or class of animal determines how it moves across the landscape and selects different forages. In the process of grazing, an animal progresses through levels of instinctive responses and behaviors that lead to the consumption of a plant (Stuth 1991). These instinctive responses and behaviors are driven by sensory cues and the physiological needs of the animal. These vary across the landscape and through time.

Factors that influence foraging behavior can be divided into two categories: factors that affect spatial choice, and factors that affect forage species choice. Spatial choice is a function of landscape features, plant community characteristics, and grazing patch attributes.

Landscape features

Foraging behavior at the landscape level is primarily a function of physical and thermal features of the range or pasture system that influence animal distribution and movement (Table 1). The array of certain features across the landscape influences how the grazing animal will utilize the range or pasture system as they seek to meet physiological needs. Physiological needs of grazing animals that determine distribution and movement across the landscape include, in order of importance to the animal:

1. thirst
2. heat/cold (thermal balance)
3. hunger
4. orientation and predator avoidance
5. rest.

Figure 2. Young steers grazing a pasture on Maui. The animals simultaneously select particular plants and plant parts as they graze.

Figure 3. Cattle and goats share a pasture on an up-country Maui ranch. The cattle graze primarily on the grasses in the pasture, while the goats browse on the shrubs and forbs.

The grazing animal must maintain water balance or die. Thus thirst is the most influential physiological need determining animal movement and distribution across the landscape. Stuth (1991) defines large ungulates as "central place foragers." That is, they have a home range that is centered on water. Cattle and sheep generally do not graze beyond 1 mile from water. Consequently, a distance between water sources of greater than 2 miles reduces grazing capacity by 50 percent. When calculating stocking rates in large pastures, managers must consider not only the spatial distribution of the herd in relation to all the water sources but also the frequency of drought. Stocking rates will need to be adjusted accordingly.

Maintaining a neutral thermal balance is a major physiological requirement for grazing animals and often takes precedence over alleviating hunger, especially when they are experiencing temperature extremes. Landscape features that provide relief from temperature extremes include trees for shade and riparian areas or gulches that provide protection from the wind. Animal thriftiness often suffers in areas where relief from temperature extremes is not available.

The final three physiological needs of the grazing animal are interrelated: mitigation of hunger (maintaining energy balance), orientation and predator avoidance, and rest. After grazing for some time, most ungulates move to loafing or bedding areas to ruminate and digest food. This will be in an area where the animal feels safe from predators or other threats. Animals generally graze first near their water and shelter areas and then move outward. The distance traveled while grazing is a function of their digestive (gut) capacity, potential harvest rate of forages encountered, grazing velocity, and level of hunger. These grazing patterns often produce rings of diminishing levels of forage utilization as distance from the water source or bedding ground increases.

Table 1. Characteristics of the landscape that affect the distribution, movement, and diet selection of grazing animals.

Attribute	*Components*
Boundaries	Fences, home range, migration routes
Distribution of plant communities	Range sites, soils, aspect, elevation, structure, species composition
Accessibility	Slope, gullies, streams, shrub density, rockiness, roads, trails, fence lines, cut openings
Distribution of important features	Location of water, shade, loafing and bedding sites, and other convergent and divergent points in a landscape

From Stuth, 1991

Plant community characteristics

A plant community is typically defined by its structural configuration, spatial arrangement, and plant species composition. Plant communities can be further divided into patches of more uniform groupings of species. The distribution of these patches influences the foraging behavior of the grazing animal within the plant community. Selection of a particular plant community by a grazing animal is largely a function of the site attributes that determine the animal's ability to harvest nutrients (Table 2).

When considered in relation to grazing by livestock, plant communities can be divided into four categories (Stuth 1991): grazing-preferred, grazing-avoided, terrain-constrained (directed-use), and high-impact (Figure 4). The bulk of the grazing animals' forage is derived from grazing-preferred sites, which have high occupancy-to-area ratios and high utilization-to-forage-mass ratios. Grazing-preferred sites typically have a greater density of high-quality forage species. This often results in slower grazing velocity and greater residence time relative to other grazing areas available to the animal. For these reasons, grazing-preferred sites can easily become overgrazed when management actions are not timely.

Grazing-avoided areas generally have low forage value, either because of the plant species composition

Table 2. Attributes at the plant community and area level that influence the animal's selection of forage sites.

Attribute	*Function affects*
Soil moisture-holding capacity	Forage supply and stability
Species composition	Suitability/stability of the site to meet general nutritional needs
Plant frequency	Probability that the animal will encounter a desirable plant species; number of dietary decisions the animal makes
Abundance	Supply of nutrients
Structure	Accessibility of forages species
Continuity	Animal movement rate
Size	Amount of search area available
Aspect	Thermal characteristics of the site
Orientation in the landscape	Frequency of exposure to grazing (position relative to other areas that meet animals needs)

From Stuth, 1991

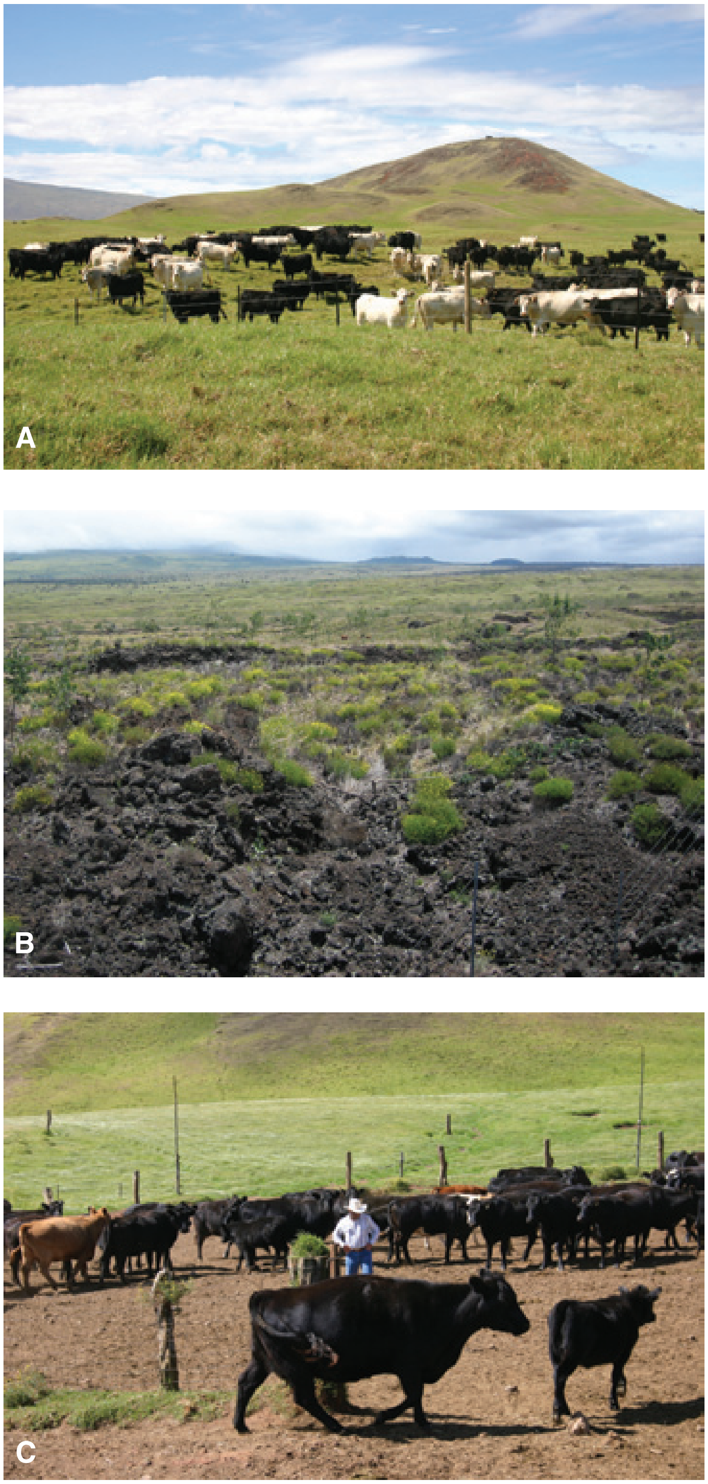

Figure 4. Grazing-preferred areas (A) provide the bulk of the forage consumed by the grazing animals. Grazing-avoided areas (B) typically have low forage value, either because of species composition or inaccessibility. High-impact grazing sites (C), sometimes referred to as "sacrifice areas," occur around water sources and along trails.

or because they are not readily accessible. Terrain-constrained (directed-use) sites generally have long occupancy time but low utilization levels, often despite abundant forage. These sites typically result from concentration of the herd in pasture corners or against gullies, hills, or roads. Finally, high-impact grazing sites have low residence times relative to the area but have high utilization levels. High-impact sites develop along directional grazing paths such as trails to water and shelter areas.

Foraging behavior and grazing management

The primary focus of a grazing management plan is to properly distribute the grazing impact across the pasture. By doing this, managers increase the quantity and quality of the forage available to the grazing animal and allow adequate recovery time for the forages between grazing events.

Poor grazing distribution within pastures has been and continues to be a major problem confronting livestock managers. On most range and pasture systems, improvement will occur without reducing livestock numbers if practices that provide more uniform grazing are implemented. Determining the appropriate practices to implement takes a thorough appreciation for the interaction between an animal's foraging behavior and factors that contribute to poor grazing distribution. Holechek et al. (1989) listed the factors that lead to poor grazing distribution, which are distance to water, rugged topography, diverse vegetation, wrong type of livestock, pests, and weather.

Improving animal distribution

Several factors can be used to improve livestock distribution in Hawai‘i, including

- changing and/or increasing the number of water sources
- increasing the number of and/or changing salt, mineral, and supplemental feed stations
- fencing
- changing the kind, class, or breed of grazing animal
- changing the grazing system
- range improvements
- construction of artificial features to provide shade or protection from wind.

Water. Poor distribution of water within the pasture is the primary cause of poor livestock distribution in most grazing systems. Grazing utilization tends to be highest near water sources and decreases with distance from water, resulting in zones of over-utilization nearby water and under-utilized pasture farther away. There is usually more under-utilized area in a pasture than over-utilized area.

Recommendations on distance between watering points depend on terrain, type of animal, and breed of livestock. Generally, distances should not exceed 0.5 mile in rough country, 1 mile in rolling or hilly country, and 2 miles in flat country. Also, the capacity of the water system (storage volume and recharge rate) must be adequate for the number of animals. Inadequate supply of water will lead to poor animal performance as they compete for water. For large pastures, a common rule of thumb is to provide one watering point for every 50 head of cattle or 300 sheep. This helps maintain animal condition and provides good grazing distribution across the pasture. In small, intensively grazed pastures, these ratios can be doubled.

Often the development of additional watering points will improve livestock distribution and productivity. New water sources can be developed by drilling wells, installing pumping units, constructing storage tanks and drinking troughs, constructing catchment reservoirs, and piping water to new locations. Each manager will need to determine what type of water development is most feasible economically. Managers should carefully select the location, number, and distribution of new watering points relative to existing ones within their pastures to improve animal distribution.

Salt, mineral, and supplemental feed stations. Careful placement of salt, mineral, and other supplements can be a great tool to obtain the desired distribution of grazing animals and can increase grazing capacity by as much as 20 percent. Livestock usually go from water to grazing and then to salt. Thus it is not necessary or desirable to place salt near watering points. In fact, strategically placing salt in grazing-avoided areas is one means to entice livestock to use these areas. Desirable areas for salt grounds include ridges, knolls, benches, and gentle slopes away from water. In large pastures, salt should be placed at the farthest distance between watering points (0.5–1 mile).

Fencing. Fencing is typically used to divide large range units into smaller units. In planning fence placement, the livestock manager should carefully consider the location, size, and shape of the grazing units as well as the direction of livestock rotation. Fences serve to (1) control the movements of livestock, (2) regulate use among forage types or protect choice grazing areas for special use, and (3) separate range or pasture units for special management.

Uniform grazing is difficult when several vegetation types (or range sites) occur in the same grazing unit. Separating large grazing units into several smaller units that are more or less similar greatly increases the uniformity of grazing. Utilization of less palatable forage species can be greatly increased by increasing the density of livestock on each unit for short periods.

Kind, class, and breed of grazing animal. Livestock typically fall into one of three groups based on their preferences for different forage types. These groups include grazers (cattle and horses) whose diet is dominated by grasses, browsers (goats) who graze primarily on forbs and shrubs, and intermediate feeders (sheep) who exhibit no particular preferences among grasses, forbs, or shrubs. Understanding these grazing preferences can help managers match the type of livestock to their range or pasture system. Moreover, multi-species grazing systems can be an effective management tool to control undesirable vegetation. For example, goats can be used to reduce cover of undesirable shrubs and encourage better production of grasses for cattle production.

Within a species, different types of animals use the rangeland or pasture system differently. For example, yearling cattle will use rugged terrain better and will range farther away from water than cows with calves. Likewise, some breeds of cattle will make better use of rough terrain than other breeds, and still others are more suited to dry country than others. Selection of the proper breed and type of cattle for your operation can be, therefore, an important decision.

Grazing systems. There are many different types of grazing system, and a full discussion of all the variations is beyond the scope of this publication. Discussion here is limited to a brief description of the different systems typically used and conditions where they are most effective.

Factors that need to be carefully considered when selecting a grazing system include climate, topography, vegetation, kind or class of livestock, wildlife needs, watershed protection, labor requirements, and fencing

Figure 5. An example of a continuously grazed pasture along the Hāmākua coast showing signs of overgrazing: severe erosion, encroachment of weeds, and low vigor of desirable forages, resulting from long-term, chronic overgrazing with a stock density that is too high.

and water development costs. Each type of grazing system carries with it a different set of costs for development and maintenance. Likewise, each system requires a different level of labor input. Finally, there is no one system that is best in all situations.

Continuous grazing (continuous stocking, or set stock). A continuous grazing system is one in which the pasture is continually stocked with livestock. It is widely speculated that this type of grazing program results in overgrazing of desirable grasses, but this is not supported in the literature (Holechek et al. 1989). The advantage of continuous grazing over other systems is also part of the problem. Under good management, continuous grazing allows the animals to select the most nutritious diet over the greatest period of time. Thus, their production relative to animals in other systems may be higher. However, this selectivity is typically problematic over the long term and often results in areas of overgrazing (preferred-use areas). These are in areas where forage, water, and cover are in close proximity (Figure 5). This type of grazing system is most suited to areas where landscape features and the vegetation type, quantity, and quality are relatively uniform over large expanses. For example, this grazing system is typically used in dry desert environments where forage production is very low, such as west Texas. In this type of system, pastures need to be large and stock density needs to be very low to avoid overutilization of grazing preferred areas. Very few areas in Hawai‘i are suited to continuous grazing; most of these are located in the leeward ranges of the island of Hawai‘i.

Deferred rotation. This system involves using multiple pastures (usually two, but sometimes more) that are periodically or seasonally deferred from grazing (ungrazed for a particular season of year) on a rotational basis. The period between deferments for a given pasture varies depending on the total number of pastures in the system. This system provides a better opportunity for preferred plants to maintain vigor than does continuous grazing. Typically this system is best suited to large operations with pastures having different seasons of production or different forage types. For example, a deferred-rotation system would work well for large ranches in Hawai‘i that have high-elevation kikuyugrass pastures and low-elevation guineagrass pastures.

Rest rotation. This system incorporates a 12-month rest period for one pasture while the remaining pastures absorb the grazing pressure. However, the benefits from the year-long rest on one pasture may be lost to the extra use that occurs in the grazed pastures. Pastures are alternately rested in successive years. This system is best suited for medium to large operations that have relatively uniform forage type, production, and quality across all pastures. Annual stocking rates need to be estimated based on the pastures being utilized for any given year.

High-intensity–low-frequency (HILF). This system of rotation grazing typically involves three or more pastures, with grazing periods longer than two weeks and periods of non-use extending beyond 60 days. An important feature of this grazing system is that it forces the livestock to use all of the available forages in the pasture more uniformly. This reduces the competition between palatable and less palatable forage species and prevents undesirable shifts in species composition. The extended periods of non-use are intended to offset the heavy use levels that occur during grazing.

Animal performance under HILF grazing is reduced compared to animals on continuous grazing programs because their average diet is of lower quality. However, under the right conditions HILF can result in a higher carrying capacity, perhaps offsetting the loss in average animal performance. The HILF grazing system works best in flat, humid rangelands such as in the tropical and subtropical ranges in Hawai‘i where recovery from grazing is rapid (Figure 6). HILF is not a suitable grazing system for rugged, arid rangelands such as are found on the leeward sides of Hawai‘i and Maui.

Figure 6. An example of a well managed high-intensity–low-frequency (HILF) grazing system in Hawai‘i. Note the different degrees of pasture growth. Dark green pastures have fully recovered and are ready to graze, brown pastures have recently been taken out of grazing, the light green pasture at right has been out of grazing for a couple of weeks, and the pasture with the cattle is nearing full utilization.

Short-duration (SD, SD–high intensity, cell grazing). Short-duration grazing systems typically involve multiple pastures arranged in a wagon-wheel pattern with water and livestock handling facilities located in the center of the wheel. However, SD grazing can be applied without the use of the wheel arrangement, which is now discouraged because of the large impact caused by concentrating animals continuously in the center.

Ideally, the grazing period for each paddock is short (five days or less) followed by four to six weeks of non-use. Typically, livestock are moved more quickly during active growth periods than during slow growth or dormant periods. The high stock density (numbers of animals per unit area) is thought to

- improve water infiltration through animal hoof action
- increase mineral cycling
- reduce animal selectivity
- improve forage plant leaf area index
- give more even use of the range or pasture system
- increase the availability of green forage
- reduce the percentage of ungrazed plants.

Like HILF grazing, SD grazing works best in flat, humid regions with extended periods of plant growth. It is successfully utilized in Hawai‘i on windward and low- to mid-elevation ranges. It is not suitable for windy, rugged ranges on the leeward slopes of the islands.

Range improvements

Several techniques can be used to improve range or pasture condition, including fertilizer application, prescribed burning, mowing, inter-seeding with more desirable forage species, and irrigation. Often the additional cost associated with the implementation of one or more range improvement practice is offset by the increased grazing capacity of the range or pasture system. While the primary focus of implementing most range improvement practices is to increase the quality and quantity of forages available in the pasture, another equally important outcome is improved animal distribution.

Figure 7. Light applications of lime (2.5 tons/acre $CaCO_3$) and nitrogen (69 lb/acre N) effectively increase forage quantity and quality in pastures converted from former sugarcane and pineapple lands. Note the difference in plant vigor between the treated plot (application of N and $CaCO_3$) on the right and the untreated plot on the left three months after treatment.

The use of fertilizers to increase production and achieve a better animal distribution on range and pasture systems is well documented for most temperate systems (see Herbel 1963, Graves and McMurphy 1969, and Wight and Black 1979). Amendments also enhance the mineral cycling in the range or pasture ecosystem. In Hawaiʻi, the addition of small amounts of agricultural lime ($CaCO_3$; 2.5 tons/acre) and nitrogen (69 lb/acre) are very effective in increasing production of desirable forages on former sugarcane and pineapple lands (Figure 7). Strategic applications of soil amendments can be used to draw animals into areas that otherwise receive little or no use.

Prescribed burning is an effective tool to reduce old growth, burn out weedy species, and improve grazing distribution. The accumulation of litter in excess of 1600 lb/acre can cause a reduction in bacterial activity necessary for sustaining decomposition of organic matter in the soil due to reduced soil temperatures. Although slowed, the breakdown of that litter also ties up nutrients in the system so that they are unavailable for plant growth. Finally, a heavy accumulation of litter slows the cycling of nitrogen within the system. Burn prescriptions can be developed to remove litter build-up and, with proper time for recovery, increase the quality and quantity of forages in areas previously under-utilized. While the judicious use of fire has been shown to be effective in many regions of the world, it is not commonly used in Hawaiʻi. However, prescribed burning in Hawaiʻi has a great potential to be an important tool for managers interested in controlling many kinds of invasive species and improving pasture condition.

Mowing is commonly used in Hawaiʻi to remove old, poor quality forage in guineagrass pastures. While this method helps managers maintain the quality of these pastures, the cost of equipment, maintenance (parts), fuel, and man-hours makes it one of the most expensive range-improvement techniques. It is most beneficial where stocking rates are insufficient to keep up with the rapid growth of the forages. Mowing can also be effectively employed to reduce the cover of undesirable shrubs and weeds.

Where mowing is used, the period between mowing and grazing needs to be long enough that forage vigor recovers. The grazing capacity of a mowed pasture should be based on the amount of new growth available. This will help ensure a suitable grazing intensity and distribution and provide a more uniform allocation of forage quality and quantity for the grazing animals.

Inter-seeding desirable forages into range and pasture areas can be used to increase forage quality and quantity and encourage grazing in areas that receive little or no use (Figure 8). This practice has many of the same costs as mowing. However, it generally has a longer life. While the benefit of mowing is short-lived and must be repeated frequently, the benefits of inter-seeding can last for several years. The longevity of the seeding and how frequently it needs to be repeated depends on what is seeded. For example, seeding with annual forages must be repeated more frequently than seeding with perennial forages. Also, some forage species can persist for only a few years under grazing, while others may persist for decades. For these reasons, the costs and benefits of seeding various forages should be carefully evaluated.

Figure 8. Perennial peanut (with yellow flower) inter-seeded into a stand of signalgrass as part of a pasture improvement project on former sugarcane land along the Hāmākua coast.

Irrigation of forages is not a common practice in Hawai‘i. Still, where water is available, irrigation of rangeland or pastureland can dramatically increase the quantity and quality of forage available. Sources of irrigation water in Hawai‘i include domestic water supplies, wells, rainfall catchments, and streams. Each of these sources has different associated costs. While drawing water from domestic sources may be less expensive to develop, it is a continual expense. On the other hand, the high initial cost of infrastructure development for wells and catchments is greatly reduced when spread over the lifespan of such developments.

Delivery of the water to the range or pasture system can be accomplished in a number of ways. Water can be transmitted from the source to the site of irrigation via pipe or ditches. It can be spread over the land surface via sprinklers, flooding, or by a series of spreader trenches. Obviously there are different costs associated with each system, and the manager needs to determine which would work best for the particular situation.

Construction of shelters

Recall that the second most critical element determining how an animal moves across the landscape is the maintenance of thermal balance. Thus, while it is not common practice in Hawai‘i, the construction of shelters to provide livestock with relief from sun and wind will greatly improve their performance. In addition, shelters can be strategically placed in order to draw animals into areas that would otherwise receive little or no use. Many areas in Hawai‘i lack sufficient shelter for livestock. It is in these areas that the construction of shelters will have the greatest benefit relative to the initial cost of construction. Planted shelterbelts with various tree or large shrub species can also be used to provide adequate shelter for livestock.

Summary

Foraging behavior of livestock is an important consideration in developing a grazing management plan. The livestock manager that fully appreciates how animals move across the landscape and the factors influencing those movements will be able to capitalize on those factors to improve grazing use and distribution. Managers can use many techniques to influence an animal's foraging behavior and achieve a better distribution of animals. It is important that the manager carefully consider all the costs and benefits before implementing such practices. In this way a manager will be sure to choose only those practices that fit the situation and provide the best return on investment.

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