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Grazing Principles for Profitable and Regenerative Resource Management Series:

III. FACTORS AFFECTING THE MAGNITUDE OF GRAZING EFFECTS ON PLANT RESPONSES AND FORAGE QUALITY

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This is the third in a series of Texas A&M AgriLife Extension publications to help readers better understand the ecology of grazed lands, the way plants grow, develop, and react to **defoliation** by **herbivores**, how to manage forage quality and quantity, management of stocking rate to improve grazing profitability, essential concepts related to proper grazing management, and how to apply these concepts successfully using adaptive grazing management strategies. We suggest you read these in order, but each can be read separately if you already have a firm background in these topics. A complete glossary of technical terms used throughout all of the publications can be found at the back of each publication. Several of these terms were supplied by the Society for Range Management, and their definitions are placed in quotes.[1] When needed, additional clarification is provided. When a technical term is used for the first time in each publication, it is shown in boldface type.

Other Titles in the Principles of Regenerative Grazing Management Series

- I. Ecological Concepts in an Economic Context
- II. Grazing Management and Its Effects on Plant Competition at Different Scales
- IV. Stocking Rate: The Essential Concept for Profitable and Regenerative Grazing Management
- V. Essential Concepts Necessary for Adaptive Multi-paddock Grazing Management to Achieve Desired Livestock and Landscape Goals
- VI. Using Essential Grazing Concepts to Properly Implement Successful Adaptive, Multi-paddock Grazing Strategies

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INTRODUCTION

In the second installment of this series, the effects of grazing on both a landscape and an individual plant scale were discussed. Generally, leaf removal has a detrimental short-term effect on the plant chosen. If repeatedly grazed, the ability of a plant to compete with its neighbors for soil moisture and nutrients may be diminished, especially in times of stress, like drought. However, depending on how these defoliation events are managed, we can either help or hurt desired plants' chances in the competition for resources with less desirable neighbors. The following is a discussion of factors to consider to achieve the desired results.

FACTORS AFFECTING THE MAGNITUDE OF GRAZING EFFECTS

The magnitude of the effect that grazing has on an individual plant depends on the timing and frequency of grazing, the intensity of grazing, and the opportunity for regrowth (TIO). The timing of grazing refers to the plant's growth stage when it is grazed and the frequency with which it is grazed by an animal. Intensity refers to "the amount of photosynthetically active (leaf) material remaining for the plant to recover from defoliation."[2] The opportunity to regrow is related to the extent to which defoliated plants are able to regrow and restore photosynthetic capacity after being grazed and before being regrazed. If a plant is grazed late in the season when the growing point is elevating or at a time when it is too dry for regrowth to occur, the harmful effects of a given intensity or frequency will be more severe than if it occurs at a time when growth conditions are near their peak. A severely grazed plant would, therefore, require a longer period of nonuse (recovery) during poor growing conditions than when conditions were more suitable for growth. How these three factors are

[1](Society for Range Management, 2005)
[2](Reed et al., 1999)

manipulated determines the effects of grazing at both individual plant and landscape scales. The distribution of the animals may also affect the severity and scale of these effects. For instance, animals concentrate on areas near water, shade, or areas of enhanced soil moisture. These areas will receive more frequent and intense grazing than areas that are steeper, rockier, or further from water if grazing periods are very long, even when moderately or lightly stocked, overall.

Figure 1. Water points are typically areas where severe and frequent grazing occur and are often a focal point of range degradation under continuous grazing. However, even when grazing use is severe, these areas can be maintained or improved with sufficient recovery afterward. The photo above was taken in April, after grazing in December. The dark-green grasses are western wheatgrass, a palatable cool-season perennial grass, while lighter-colored grasses are blue grama and buffalograss. With continuous grazing, this area would become severely degraded as a result of compacted soils with poor structure and high proportions of bare ground. Note the small water lot around the trough and the subdivision power fence, indicated by the arrow, used to shorten grazing periods and provide a period of nonuse based on growing conditions to allow plants to recover from grazing. *Photo courtesy of Tim Steffens.*

Figure 2. This photo was taken from an angle slightly to the left of the previous one at the same water point the following July. Adequate rainfall and the growing season grazing deferment has allowed the grasses to make a full recovery, with palatable perennial grasses growing right to the gates of the water lot around the trough. *Photo courtesy of Tim Steffens.*

The S-shaped Growth Curve and Its Significance in a Plant Context

Figure 3 will be helpful to discuss plant-animal interactions associated with the grazing process. The solid line in the diagram represents a growth curve for grasses in a plant community. Growth is relatively slow early in development if measured by weight increase per unit of time (phase I on the left of the figure). Phase I is followed by a rapid growth period, designated as phase II in the diagram. At some point, plant growth rate decreases before setting seed and going dormant or dying (phase III on the diagram).

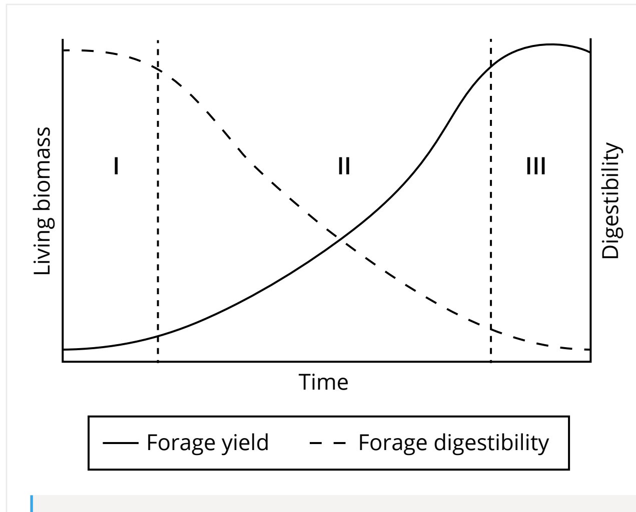

Figure 3. The relationship between forage quality and quantity in a plant community. *Adapted from Voisin, Smith et al.*[3, 4]

In humans, phase I would be referred to as infancy and childhood. Phase II would be similar to early childhood and adolescence. Phase III would be middle into old age. In grasses, phase I is the seedling, or in the case of perennial grasses, early shoot growth from the crown. Phase II is the period of rapid growth when leaf area and age are sufficient for high rates of photosynthesis. Generally, this phase is when individual stems contain three to six vigorous leaves. Keep in mind that phase II in drier climates may actually have periods of relatively steep and relatively flat growth rates as soils dry and rewet. Phase III begins about the time the seed head is forming and continues until dormancy or death.

Anything that increases the growth rate makes phase II begin quicker, increases forage quantity, and decreases quality over a shorter time period. Conditions that increase growth rate vary with plant species. Cool-season plants generally grow best when soil moisture is near field capacity, and temperatures are about 70 to 75°F. Temperatures of 85 to 90°F are usually considered

[3](Voisin, 1988)
[4](Smith et al., 1986)

optimum for warm-season plants. Precipitation at a time when temperatures are optimum for a particular plant will favor that plant over other types with a different optimum.

Both phases I and III are energy inefficient regarding the amount of total sunlight, water, and soil nutrients turned into plant material through photosynthesis. They may even be a net energy drain to the plant. In phase I, insufficient leaf material is available to manufacture the energy necessary to support growth and maintenance of the plant. In phase III, the buildup of aging leaves and damage to the waxy covering of older leaves may cause them to lose more water compared to younger, undamaged leaves. The quantity and vigor of leaves in phase II make this the most efficient phase of growth.

The time when a single defoliation has the most detrimental effect on a grass plant is when the growth point is elevating (the "boot" stage). At this time, the plant already has committed large amounts of energy to seed production, and leaves may be older and damaged from weather, insects, etc., with decreased photosynthetic efficiency. The growing point is usually elevated near the end of the growing season, leaving only limited regrowth opportunity if the growing point and leaf material are removed through grazing. Defoliation at that time will set the plant back to phase I with little chance to recover before dormancy or death.

Grazing a plant in phase I will cause an energy drain and may set the plant's rate of maturity back. However, this period is usually early in the season, when conditions are—or are likely to become—relatively good, and the growing point is close to the ground and not as likely to be removed by the animal, so a single defoliation at this time is not as critical. Regrowth of plants that were defoliated earlier will be more palatable and nutritious than ungrazed plants that are more mature. The real danger is that long grazing periods during the early growth stages will increase the chance that the plant will be grazed again before it recovers, keeping it in phase I for a longer period and preventing it from attaining a sufficient level of photosynthesis to maintain itself. If continued, the repeated defoliation could cause the plant to die.

In moist regions where growth can occur over long periods, removal of the growing point may promote dormant buds at the base of the plant to begin growth, which can increase the size of the grass crown and thicken the stand, much as mowing can thicken the turf of a lawn. However, when growing conditions are only occasionally optimum and occur for only short periods at a time, there may not be good growing conditions for long enough to accomplish this increased density of tillers, particularly if grazing periods are long.

If the plant is in phase II, the amount of energy produced by the leaves is greater than the amount being used for growth. If excessive amounts of leaf material are not removed and growing conditions remain good, the plant could theoretically stay in phase II until dormancy. Grazing animals, unfortunately, have not read many books on proper grazing use and often graze palatable plants excessively, setting them back to phase I. Even if this setback occurs, however, the plant can resume growth and recover with little effect on plant vigor and production if an adequate recovery period is allowed during a time when growing conditions are suitable. Therefore, our goal as managers, from a plant standpoint, should be to keep them in phase II as much as possible through moderate average defoliation levels and avoiding defoliating plants repeatedly at critical periods in their life cycle. Allowing enough recovery for existing forage plants to maintain vigor and set seed occasionally will maintain a viable seedbank in the soil.

Figure 4. Grazing animals will often regraze plants that have been previously defoliated as they regrow because the new regrowth is of higher quality than the more mature growth that was not previously grazed. As a result, there will be some plants that remain in phase I for extended periods of time (blue arrow) and some that are in phase III (yellow arrows) for extended periods—both of which are energy inefficient and decrease forage productivity. Plants in phase III are of lower nutritional quality and will be unpalatable to grazers. Repeated defoliations decrease the effective rooting depth, leaf area capable of carrying on photosynthesis, and the plants' ability to compete for soil resources with ungrazed neighbors. Insufficient recovery between grazing events is referred to as **overgrazing** and can occur even at light to moderate stocking rates, as in this photograph. Without enough grazing deferment to regrow a full complement of roots and leaves, these "grazing lawns" become focal points of further landscape degradation, decreasing plant productivity and livestock carrying capacity. *Photo courtesy of Tim Steffens.*

The S-shaped Growth Curve and its Significance in an Animal Context

The discussion in this section is drawn heavily from an excellent book chapter by Rittenhouse and Roath.[5] For more detail, please read the chapter listed in the "Bibliography" section. The dotted line in Figure 1 represents forage digestibility—the concentration of digestible energy per unit of plant material and the rate at which it becomes available in the gut of the animal—as a plant matures. The nutrient intake of an animal depends on the quality and quantity of available feed.

Each plant cell contains sugars, proteins, amino acids, and other compounds that are rapidly and almost completely digested by the animal. These compounds, however, are surrounded by a cell wall composed of cellulose and other structural compounds that are less rapidly and less completely digested and are only available to the animal after microbial breakdown in the gut of a **ruminant** animal like a cow or sheep. As a plant matures, the cell wall thickens, and the proportion of lignin (wood) and other indigestible or slowly digestible compounds in it increases. The rate of cell wall digestion by rumen microbes also decreases with plant maturity. The highly digestible cell contents begin to represent a lower percentage of the plant, and since the cell wall must be penetrated before the cell contents can be digested, the cell contents are also less available to the animal.

In the early stages of growth (phase I in Figure 3), forage quality is high, but quantity is low. This situation would allow animals to select a high-quality diet, but they would be unable to eat enough of the limited amount available, causing low levels of intake and performance. Consequently, if the animals have relatively high nutrient demands, they would lose weight since the high quality will not fully compensate for the small amounts of feed they can consume.

As plants reach maturity and go dormant (phase III), the quantity of available forage may be high, but forage quality is low because of low protein and high proportions of cell wall. The low protein content decreases the ability of the rumen microbes to digest plant cell walls, since they need the nitrogen in this protein to break down the chemical bonds of the cellulose and turn it into energy for the animal. Therefore, even the digestible portions of cell walls become more slowly digestible. The low quality will decrease both the nutrient concentration of the diet and the rate at which it can be digested and passed through the animal. Since the intake of a grazing ruminant is initially limited by fill and then by the rate of disappearance from the digestive tract, the decreased rate of digestion/passage would doubly penalize the animal, since it will be able to consume less of a low-quality diet.

In the middle parts of the growth curve (phase II), quantity and quality are both high enough that they result in adequate animal performance. The goal of a manager from an animal perspective, therefore, should be to graze vegetation in phase II as much as possible, with the caveat that they are not grazed so frequently that plant vigor suffers. By doing so, the density of desirable plants will not diminish over time. It is important to remember that plant maturity is a result of the relative development of the plant and not the time of year. Though plants tend to mature as the season progresses, the rate of growth and growing conditions modify the rate at which quality decreases because the number and weight of reproductive stems produced per acre decrease in dry conditions, making the ratio of leaves to stems higher under drier conditions.

Water stress usually slows growth and, therefore, also slows the rate of maturity. As a result, grasses also usually produce fewer flowering tillers under moisture stress, reducing the total yield but increasing leaf to stem ratios, thereby increasing the proportion of higher-quality plant parts but decreasing availability. This longer period of high quality is one reason weaning weights may remain good during the early stages of a drought before stocking rates exceed available forage, and why many people refer to grass from drier regions as being "strong."

When moisture is not limiting and temperatures are favorable for growth, the increased rate of maturity results in increased proportions of cell wall and lignin and a decrease in crude protein, cell contents, and soluble carbohydrates if plant maturity is not set back by grazing and regrowth. These faster rates of grass growth and maturity in warmer, wetter climates cause grasses to lose quality rapidly and leads to the term "washy" grass in humid climates.

Other plant-related factors that affect diet quality include the availability of nitrogen-containing compounds in the plant to promote rumen microbial growth and the breakdown of cell walls. The diversity of species available to the animal will also affect diet quality. In general, warm-season grasses are less digestible than cool-season grasses *at the same stage of maturity.* **Forbs** will have a higher percentage of cell contents and crude protein at a given maturity than grasses but lose this advantage after **dormancy.** Shrubs often contain a higher percentage of lignin than forbs or grasses, but often contain higher levels of protein and phosphorus than grasses or forbs, especially during

[5](Rittenhouse and Roath, 1987)

the dormant season. Some shrubs and forbs may also contain secondary compounds that affect plant digestibility or cause toxicity.

Reduced light, as occurs when plants are growing under dense shade, tends to increase the percentages of cell wall and lignin while it decreases yields and levels of highly digestible compounds. Crude protein levels also increase, but a large proportion of this crude protein is nitrate and other non-protein nitrogen, which may cause "nitrate poisoning."

Nutrients may be moved below ground as temperatures and day lengths decrease in the fall, lowering forage quality. As the dormant season progresses, leaf loss due to weathering and microbial action may further aggravate this problem since the remaining stem is generally of lower quality than leaves.

Plant Adaptations to Grazing

Plant adaptations to grazing can be grouped into two categories: tolerance or avoidance. Plants that employ tolerance mechanisms are often palatable and grazed by animals when they are present. Tolerance mechanisms that allow plants to be grazed without long-term harmful effects include the ability to change shape, structure, stature, or leaf arrangement and the use of alternate forms of reproduction. When some plants are repeatedly defoliated, they change their stature or the structure of the leaves or stems in an attempt to maintain enough leaf area to support photosynthesis and protect their growing points. Examples include the lower, denser vegetation of a well-tended lawn compared to an unmown lawn. The "hedged" appearance of some shrubs, where the leaves grow among a dense growth of twigs, making them less available and less likely to be browsed, is another example. Alternate forms of reproduction include rhizomes, stolons (runners), and recruitment of additional stems from secondary buds.

Caldwell et al. also found that some species change the way they allocate energy from root to shoot growth more rapidly compared to other species following grazing.[6] By doing so, they are able to regrow quicker and maintain their competitive ability for resources compared to other species that are slower to respond. This rapid reallocation of resources is another means by which plants tolerate grazing.

Avoidance mechanisms include plant structures that make excessive removal of leaf material or growing points more difficult for grazing animals. This avoidance mechanism is commonly seen in short grasses and some annual plants. Another avoidance mechanism is the growth of specialized structures such as thorns,

Figure 5. This mountain mahogany bush is showing a hedged appearance as a result of heavy and repeated defoliation by deer and other browsers. Notice how the leaves are in small bunches and have twigs protecting them. The only long twigs are in the center of the plant and are too high for browsers to reach. This palatable browse species is difficult to increase because it will be heavily browsed if other, more palatable plants are not common enough to supply adequate forage to take some of the pressure from the browsing animals off of the mountain mahogany so it can reproduce. *Photo courtesy of Tim Steffens.*

spines, prickles, hairs, or waxy coatings, which make the plant either physically undesirable or unpalatable.

The other avoidance mechanism often seen in plants as a defense against grazing is the production of secondary compounds. All plants do this to an extent by increasing structural compounds such as cellulose and lignin as they mature. However, in this context, we refer more to compounds that affect palatability, nutrient availability, or toxicity. Often, these secondary compounds vary in concentration over time. Also, some secondary compounds offset the effects of other secondary compounds, at least partially, if both are consumed at the same time. By timing grazing events to either allow mixing of different compounds or using plants in an area when secondary compounds are particularly high or low compared to other plants in the area, we can sometimes affect which plants are chosen, the proportion, and even how intensely they are defoliated. By doing so, we can often make it easier to achieve animal and **plant community** goals. Villalba and Provenza, cited in the "Bibliography" section of this publication, provide a more detailed discussion of how animals select diets based on the consequences of ingesting plants with different types and levels of these secondary compounds and how management can affect their ability to do so.[7]

The next publication in this series discusses the importance of stocking rate in any grazing management program.

[6](Caldwell et al., 1981)
[7](Villalba and Provenza, 2009)

GLOSSARY

Aggregate A cluster of soil particles held together in a single group such as a clod or crumb. The more stable and rounder in appearance, the more desirable the aggregate **structure**.

Animal Unit Day (AUD) "The forage demand (amount of forage) on an oven-dry basis required by one animal unit for a period of one day."[1]

Animal Unit Month (AUM) "The amount of oven-dry forage (forage demand) required by one animal unit for a standardized period of 30 animal-unit-days."[1]

Animal Unit Year-long (AUY) "Equal to 12 AUMs."[1]

Area Allowance A measure of area/animal at a given point in time. It is measured in units of area/animal with no measure of time. It is the inverse of stocking density and changes linearly with increasing paddock numbers on the same land area with animal numbers remaining constant.

Biomass The amount of living material.

Browse The part of shrubs, woody vines, and trees available for animal consumption composed of leaves and small, soft twigs of palatable shrubs.[1]

Bulk Density The mass per unit of volume (e.g., pounds/cubic foot) of undisturbed soil, including air space. Within a particular soil type, lower bulk density will allow more rapid moisture infiltration and movement through the profile.

Capital Assets In the context of a business, capital assets are things with a useful life longer than a year that are used to make the products of the business. They are not intended for sale in the regular course of business operations such as machinery, buildings, or the real property where the business is located. In the case of the range resource, they would be things like seedbanks, soil organic matter, perennial plants, and water resources.

Carnivore An animal that eats other animals.

Carrying Capacity "The average number of livestock and/or wildlife that may be sustained on a management unit compatible with management objectives for the unit. In addition to site characteristics, it is a function of management goals and management intensity."[1]

Climax "The final or stable biotic community in a successional series; it is self-perpetuating and in equilibrium with the physical habitat."[1] Stress or disturbance as a result of excessive levels of grazing or other factors would cause the community to revert to a lower **successional state**. With removal of the stressor, the community would then progress through the same stages back to the stable climax community. This view of **successional** processes, however, has been unsuccessful in explaining **plant community** changes in some circumstances, particularly those where "naturalized" alien species have become an important part of the plant community, on areas where extreme degradation of the soil has occurred, or where other environmental influences like pollution or species extinction have changed the productive potential of the site.

Cycle Length The length of time required to graze all paddocks in a unit, i.e., the recovery period plus the grazing period.

Deferment "The delay of grazing to achieve a specific management objective. A strategy aimed at providing time for plant reproduction, establishment of new plants, restoration of plant vigor, a return to environmental conditions appropriate for grazing, or the accumulation of forage for later use."[1]

Defoliation "The removal of plant leaves, i.e., by grazing or browsing, cutting, chemical defoliant, or natural phenomena such as hail, fire, or frost."[1]

Disturbance A change in conditions, processes, or a stress that causes some plants to die in an area. Examples include fire, drought, excessive grazing, floods, etc.

Dormancy The period when the plant is no longer growing, usually after frost, but may also be due to drought.

Ecological Site "A kind of land with specific physical characteristics which differs from other kinds of land in its ability to produce distinctive kinds and amounts of vegetation and in its response to management."[1]

Ecological Threshold A threshold of soil or other degradation that, once crossed, changes the potential plant community for a site irreversibly on management-level time scales without high levels of management input or extended periods of time.

Ecosystem "Organisms together with their abiotic environment, forming an interacting system, inhabiting an identifiable space."[1] I.e., the plants, animals, soils, climate, and other living and non-living things that affect each other through a series of chemical and physical feedbacks.

Forb A broadleaf herbaceous plant (not a grass, sedge, or rush); often referred to as a weed.

Herbaceous Plant Plants that are not woody.

Herbage Allowance The amount of forage on offer compared to the amount that the animals can consume.

Herbivore "An animal that subsists principally or entirely on plants or plant materials."[1]

Litter "The uppermost layer of organic debris on the soil surface; essentially the freshly fallen or slightly decomposed vegetal material."[1]

Meristem A region of plant tissue—found chiefly at the growing tips of roots and shoots, at the nodes, and in grasses, at the collar of leaves and at the base of the plant—consisting of actively dividing cells forming new tissue. The growth points of the plant.

Omnivore An animal that eats both plants and animals.

Organism Any living thing.

Overgrazing "Continued heavy grazing which exceeds the recovery capacity of the plant and creates a deteriorated range."[1] It happens to individual plants and is caused by inadequate opportunity for regrowth following defoliation that weakens, and if continued, can kill that plant. Overgrazing can occur even with low stocking rates.

Overhead cost The costs, usually associated with land, facilities, or labor, that do not increase directly with the number of animals.

Overstocking "Placing a number of animals on a given area that will result in overuse if continued to the end of the planned grazing period."[1] That is, forage demand in excess of that which will meet animal production and resource goals. Overstocking will always cause one or more of the following: 1) overgrazing; 2) increased variable costs; 3) decreased animal performance; 4) lower profitability.

Paddock "A grazing area that is a subdivision of a grazing management unit and is enclosed and separated from other areas by a fence or barrier."[1] The term "pasture" is also used in the United States. However, "paddock" is used in this case because it is most often used in conjunction with controlled grazing management, whereas pasture is a term more commonly used in areas where season-long or year-long grazing is common.

Perennial A plant that has a life span of 3 or more years that regrows each year from existing crowns, stems, or roots.[1]

Photosynthesis The chemical reaction carried on by green plants in which they change carbon dioxide from the air and water absorbed from its roots to form simple compounds used for energy using the light from the sun.

Plant Community "An assemblage of plants occurring together at any point in time, thus denoting no particular successional status."[1]

Recovery Regrowth following **defoliation** sufficient for a plant to fully regain its vigor so that it can retain its competitive ability in relation to neighboring plants. With regard to a plant community, recovery may also require additional time for plants to produce reproductive parts and then germinate and establish new plants, if more desirable plants are wanted. In order to ensure recovery, a period of grazing **deferment** is usually required.

Revenue The total amount of money received as a result of doing business.

Rhizome A horizontal underground stem, usually sending out roots and aboveground shoots from the nodes that is responsible for vegetative reproduction in some plants like Johnsongrass and Tobosa.[1]

Ruminant "Even-toed, hoofed mammals that chew the cud and have a 4-chamber stomach."[1] These animals also have a dental pad in the upper jaw instead of incisor teeth, such as a cow, sheep, goat, or deer, but not a horse.

Seral "Refers to species or communities that are eventually replaced by other species or communities within a sere."[1] It is sometimes used to refer to the **successional state** of a community growing on an **ecological site.** A high seral community would have a high proportion of species that are long-lived, use resources efficiently (e.g., conserve them with little waste), and are adapted to lower levels of disturbance. Low or mid-seral communities would have a higher proportion of plants that were shorter-lived, more opportunistic, and possibly less efficient in their resource use. High, mid-, and low seral may also refer to plants characteristically found in these respective communities.

Seral Community "The relatively transitory communities that develop under plant succession. Syn. seral stage"[1]

Stocking Density "The relationship between number of animals and the specific unit of land being grazed at any one point in time. May be expressed in animal units per unit of land area (animal units at a specific time/area of land)."[1] It is the inverse of area allowance and changes asymptotically with increasing paddock numbers on the same land area when animal numbers remain constant.

Stocking Intensity The total forage demand per unit area in a paddock for a grazing period.

Stocking Rate "The relationship between the number of animals and the grazing management unit utilized over a specified time period."[1] This will be expressed in terms of animal units of forage demand over a described time period per unit of land area such as acres/cow/year, acres/animal unit × month, animal unit × days/acre, etc.[1] Therefore, it is an indirect measure of forage demand on a management unit for a grazing season or year. With continuous grazing, stocking rate and stocking intensity will be the same.

Stolon "A horizontal stem which grows along the surface of the soil and roots at the nodes."[1] These are the "runners" commonly seen in species like Buffalograss, Curly mesquite, and Bermudagrass.

Structure The characteristic size and shape of the soil aggregates.

Succession "The progressive replacement of plant communities on a site which leads to the potential natural plant community."[1]

Successional State "The present state of vegetation and soil protection of an ecological site in relation to the potential natural community for the site. Successional status is the expression of the relative degree to which kinds, proportions, and amounts of plants in a community resemble that of the potential natural community."[1] Generally, in higher seral communities, species are usually longer-lived, reproduce less often, and are generally better adapted to conditions where competition is high for limited resources and the plants are generally assumed to be better adapted to moister conditions and are more productive, though there is often much of the energy lost to respiration, such that net productivity approaches respiration.

Transpiration The loss of moisture through the leaves of plants.

Turnover The number of units produced from a given area over a period of time.

Variable costs Those costs that increase with each additional unit of production. In livestock production, usually associated with feed, veterinary costs, shearing, interest, depreciation on the livestock, etc.

Vegetative "Non-reproductive plant parts (i.e., leaf and stem) in contrast to reproductive plant parts (i.e., flower and seed) in developmental stages of plant growth. Also, the non-reproductive stage in plant development."[1] This term also may be used for classes of plants that are not woody—that is, not shrubs or trees.

Vegetative Reproduction "Production of new plants by any asexual method,"[1] e.g., from **stolons** or **rhizomes**.

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