Grazing Management Can Improve Livestock Distribution

Increasing accessible forage and effective grazing capacity

By Brien E. Norton, Matt Barnes, and Richard Teague

On the Ground

- By managing for more even animal distribution, ranch managers can increase the amount of forage accessible to livestock and raise their effective grazing capacity.
- Smaller paddocks and higher stocking density improve the distribution of grazing in each paddock.
- A landscape of many, smaller paddocks will spread grazing pressure more evenly than one of fewer, larger paddocks.

Keywords: strategic grazing management, complexity, grazing distribution, multiple-paddock grazing, paddock size.

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In practice, grazing management is simply controlling where and when animals graze over the landscape. A gifted herder can exercise this control with precision but most ranchers prefer to rely on fences to set the limits of animal movement within a paddock or grazing management unit. The size of the fenced paddock will influence the degree to which livestock can explore the entire area when left to their own devices.

The management challenge then is to manipulate land use and livestock movement so that every part of the rangeland resource supplies forage for grazing animals without some areas experiencing such heavy grazing pressure that it could lead to future invasion of weedy species or erosion from exposed bare ground. In order to achieve even distribution, every forage plant would need to be examined by a grazing animal that has the option of eating it. Working under that criterion is the essence of managing for even spatial distribution.

The strategy of expanding foraging to cover a larger portion of the total ranch area, without changing the number of animals carried on the ranch, causes the grazing impacts from those livestock to exhibit less of the extremes of high concentration and underutilization—leading to a more benign ecological impact overall.

Spatial Patterns of Grazing

Extensively Managed Grazing

In a paddock large enough to supply forage for an entire season, or longer, herds of cattle and flocks of sheep develop habits of movement that are manifest in well-trodden trails radiating from water points and shade, and create a diverse array of impacts over the landscape. They develop preferences for areas that offer more palatable or nutritious forage, or protection from uncomfortable weather. Often these location preferences relate more to initial experience when stock first wander into a fresh paddock than to inherent navigational wisdom. Or they reflect different walking behaviors by which more adventurous animals travel much further than others who are content to stay close to water and shade. The ultimate expression of livestock behavior in large paddocks is uneven distribution of grazing that concentrates grazing pressure in localized areas and leaves the remainder more or less neglected. Those areas of concentrated grazing pressure experience a *de facto* stocking rate higher than the stocking rate calculated for the paddock as a whole, potentially much higher. The elevated stocking rate makes those areas vulnerable to decline of palatable and nutritious species, loss of vegetative cover, and invasion by weedy species, both native and exotic.

The phenomenon of uneven grazing distribution in large rangeland paddocks and consequent patch degradation is well known to ranchers and has been documented from scientific observation,[1,2] but is not always predictable. The old adage that grazing pressure declines with distance from water is not reliable.[3] Uneven grazing may be less obvious in small paddocks of a few hundred acres, but can still occur if the stocking rate is low enough for the paddock to supply year-round forage.[4] The study by Senft and his colleagues[4] is particularly interesting because it shows that a light stocking rate of 10–12 steers stocked year-round in a paddock of only 320 acres on short-grass prairie spent most of their time in only half of the available area; the remainder was underutilized (Fig. 1).

From a ranch manager's point of view, uneven distribution of grazing represents both a reduced return on investment, and risk of degradation in areas the stock prefer. One could argue that poorly used areas have been neglected because livestock found them to be of lower quality forage. On the other hand, preferred patches could exhibit degradation in species composition and quality of plant growth as a result of heavy localized grazing, but stock will still graze them despite their lower condition because their nutrient density is usually higher.[4]

In this primarily conceptual article, we focus specifically on livestock production goals and the potential benefits to the rangeland resource and animal production that can come from more even distribution of grazing animals. Alternative goals embracing wildlife outcomes may be satisfied by managing for heterogeneity in vegetation structure and composition fostered by patchy grazing,[5] although in some cases rotational grazing could facilitate management for a wildlife objective.[6]

Intensively Managed Grazing

It is tempting to imagine that even distribution of grazing implies a mowed-lawn effect—that when we talk about even distribution of grazing we mean an even grazing impact with vegetation reduced to the same homogeneous stubble height. We have seen such an outcome, but it is uncommon for intensive grazing over short periods. Grazing lawns may be observed in heavily grazed patches under continuous use at relatively low stocking rates for the overall paddock. The expectation of a mowed-lawn grazing impact under intensive management has lingered on, however, fostered by past research studies in which small plots were mowed or clipped evenly to simulate grazing.

More usually, there is uneven utilization at a small scale, resulting in uneven stubble heights and some plants not touched, even in small paddocks grazed at high stock density for a short time. We emphasize that the concept of spatially even distribution of grazing is creating the *opportunity* for grazing animals to encounter the entire array of forage plants present in the paddock, within a period of days or a few weeks. It is exposure of all individual plants to one or some of the herbivores; it is not a requirement for every animal to inspect every plant. What happens by way of defoliation after that exposure is up to the grazing animals.

Given the ability of ruminants to select a more nutritious diet from the average quality of the material on offer, consuming forage from neglected areas that exhibit poorer-quality vegetation will likely not impair animal production in the short term, if grazing is managed such that animals mix forage of high and low quality over short time periods in small paddocks, spreading the use of high- and low-quality forages across the season at the landscape scale.

Not All Forage Is Available

We often think of "available" forage as comprising every plant that grows within a fenced paddock, but that is an unrealistic characterization of "availability." Plants in some parts of the paddock are simply outside the habitual orbit of livestock movements, which is often the case in large paddocks, especially if conservatively stocked. Ultimately, the amount of forage that is realistically available to grazing animals is the amount they are likely to encounter while grazing.

This forage that they are likely to encounter is less than the biomass we calculate for an entire paddock that is conservatively stocked. It is the total forage in the paddock adjusted for type of animal, their diet preferences, the distance those animals normally travel in a foraging expedition, location of shade and water, social behavior that influences direction and pace of movement, habits of movement around the paddock reinforced by length of stay, physiological condition of the animals, and topographic impediments within the paddock.

In large paddocks, livestock visit only a fraction of the calculated forage present in the paddock when those adjustments are taken into account.

The Supermarket Analogy

Patterns of livestock foraging can be illustrated by one type of human foraging behavior. In one sense the food available to us is the sum total of all the shelves stocked with food in all the supermarkets in town, but in practice we restrict that availability. Left to our own devices, we prefer certain supermarkets over others, and within those supermarkets we routinely go to some aisles and shelves and ignore others. We have our own patterns of grazing distribution, and the more places available to us for shopping, the more uneven our foraging becomes. Our behavior, along with which supermarkets are available in our foraging area, shapes the food that we encounter and choose from, and if we routinely ignore or neglect some supermarkets, their food on offer is *effectively* no longer available to us.

Continuing with the shopping analogy, imagine if there were a manager of supermarket-shopping opportunities who determined that only one supermarket would be open at a time, and when it closed another supermarket opened, until eventually all supermarkets in town were exposed to consumers one at a time. As shoppers, we would be forced to spread our purchases across a wider range of opportunities, but although some of the brands may differ, the quality of our consumption may not change significantly.

Let us further assume that the length of time a supermarket stayed open was proportional to the amount of food on its shelves. From the supermarkets' point of view, the consumer impact would be spread more evenly, with previously neglected supermarkets gaining in contribution to society and previously overutilized supermarkets seeing some trade transferred to competitors. From the consumers' point of view, we would be unable to concentrate our shopping impacts on a narrow range of preferred stores. Our personal preference to shop in certain places would be overridden by the manager of supermarket-shopping opportunities.

Increasing Effective Grazing Capacity

A Hypothetical Example

A hypothetical example emerges from the study by Richard Senft and his colleagues,[4] who mapped growing- and dormant-season utilization for a 320-acre paddock, stocked with 10–12 steers for 2 years (Fig. 1). The positions of steers and their behavior were recorded on a paddock map every 15 minutes during six 4-hour observation periods per month. The 320-acre field is on the USDA-ARS Central Plains Experimental Range in northeastern Colorado, where most of the precipitation falls as rain during the growing season. The dominant short grasses are blue grama (*Bouteloua gracilis*) and buffalo grass (*Buchloe dactyloides*), and their occurrence matched preferred grazing areas, which varied somewhat with season.

The clear parts of the two paddock maps in Figure 1 are areas where the steers spent less than 4 hours grazing per acre per month, compared to more than 60 hours grazing per acre each month for the heaviest grazing pressure (darkest portions of the maps). If these two maps (growing and dormant season) are superimposed on one another, the combined neglected area comprises about half the total 320 acres. If a manager overrides animal preference and installs a grid of electric fencing that divides the area into 20 paddocks of 16 acres each, the forage in those previously neglected areas would be grazed, and the grazing pressure on previously heavily used areas would be relaxed.

By grazing the paddocks for a hypothetical period of 9 days on average, each paddock would be grazed only twice a year and experience a resting interval of more than 24 weeks. There are three important outcomes from such a management regime: 1) those previously heavily grazed patches no longer experience a *de facto* very high stocking rate; 2) the paddocks have about 6 months to recover from defoliation; and 3) the steers effectively have access to twice as much forage as they used to. It is reasonable to assume that more than 12 steers could be safely carried year-round under those conditions.

If the grazing period were reduced to less than 9 days, during the growing season for example, the resting interval would also shrink. Similarly, an increase in grazing period during the dormant season would expand the length of the rest period.

In a real-ranch situation, the grazing periods for paddock subdivisions would vary according to climate, season, and pasture and animal condition. By monitoring pasture and animal condition, and observing forage standing in paddocks yet to be grazed in a rotation cycle, a manager can adjust the grazing period for individual paddocks, and ensure that a paddock is not grazed at the same time every year. There is no formula that dictates how a ranch should be subdivided to achieve an optimal paddock size. Subdivision strategy will be guided by location of existing fences, water-points, roads, and topographic features.

a)

b)

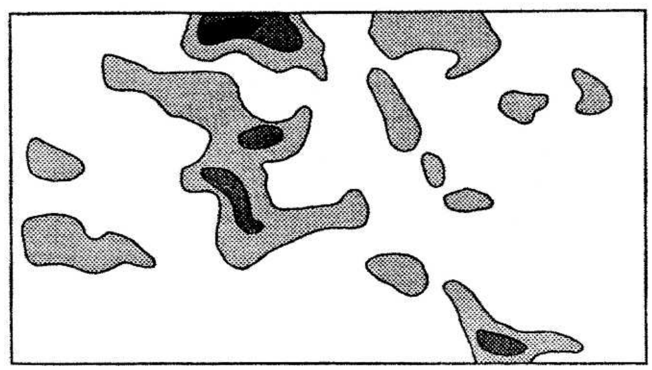

Figure 1. Maps of paddock utilization in a 320-acre paddock in eastern Colorado by 10–12 steers for two grazing seasons: April–October (**a**) and November–March (**b**). The single water point is located at the middle of the northern boundary. Data were collected over 2 years by observing animal position and activity every 15 minutes for six 4-hour periods per month. The clear areas in the map represent less than 4 hours grazing per acre per month; the darkest areas of the maps represent more than 60 hours grazing per acre per month. The Figure is derived from figure 2 in Senft et al. (1985).[4]

From personal experience in several countries, we note that ranchers often begin with the subdivision of a large paddock into four or five smaller paddocks, see some benefits within a few years, and then carry out further subdivision. It is usually an incremental process that fits the style and skill of the management team. The more subdivisions within a rotation cycle, the greater the managerial flexibility to vary the grazing period, even leaving a paddock ungrazed if conditions warrant. However, because management results are also impacted by location, climate, season, vegetation type, and other external factors, we are reluctant to offer a prescription for landscape subdivision and the rotational grazing management that follows, beyond identifying some general principles to consider.

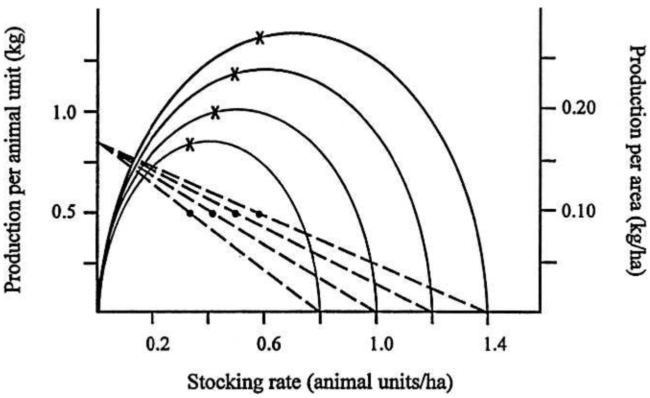

Figure 2. A set of production curves showing the relationship between stocking rate and animal production per head (dashed lines) and per area (sold lines), based on the model of Jones and Sandland (1974).[7] The y-axis intercept shows the highest production per head at minimum stocking rate; intercepts on the x-axis show the stocking rate at which weight gain is zero. An x-axis intercept point depends on the amount of forage. As grazing management increases the forage accessible to livestock through more even distribution of grazing, more animals can be carried before zero weight gain is reached. The production per head travels horizontally from point to point on the dashed lines, and the corresponding production per hectare moves up from one "x" to another on the area productivity curves. Figure from Norton (1998).[8]

A Theoretical Model

The increase in grazing capacity from more even distribution of grazing, as illustrated in the companion case study by Barnes and Howell (*this issue*), can be demonstrated theoretically from the relationship between animal production and stocking rate (*see Frasier and Steffens, this issue*), which as usually presented does not account for changes in spatial or temporal grazing patterns. Consider the consequences of a change in management that increases the amount of forage that livestock encounter. Figure 2 is a modification of the Jones and Sandland model for the effect of stocking rate on livestock production per head and per area:[7] new curves are drawn when a change in the amount of forage results in changes in grazing capacity and thus in stocking rate along the x-axis.[8]

While the point at which the production-per-head line intercepts the y-axis (the maximum productivity of a healthy animal) is a function of forage quality, the intercept on the x-axis (stocking rate) is dependent upon the amount of forage that livestock encounter in the paddock. The x-intercept is the stocking rate at which weight gain is zero. If animals are presented with more forage, by being placed in parts of the landscape that are underutilized, for example, the stocking rate for zero weight gain is expected to increase, and the maximum animal productivity per acre will rise concurrently. These shifts could result from an increase in either forage encountered, or forage quality (if more desirable species composition develops), or both.

The Rex Ranch Example

The data points on the two sets of lines in Figure 2 are close to the results obtained at the Abbott Unit of the Rex Ranch, Nebraska, following subdivision of paddocks and the introduction of rotational grazing. The ranch is located in the heart of the Nebraska Sandhills, 20 miles south of Ashby, Nebraska, and receives an annual average total precipitation of 18 inches, mostly in the late spring and summer. The ranch is about 57,00 acres in area, and had about 5,000 head of cattle on hand in 1997, of which around 2,150 were breeding cows. By 1997, the rotation cycle included a minimum rest period of 30 days in the growing season, and a rest of 90–120 days during the dormant season. Over a 4-year period from 1994 to 1997, as subdivision and rotational management progressed, stocking rate steadily increased until it was double the initial rate. Production per animal scarcely declined during this time, while production per area rose from 12.5 to 32.5 pound/acre (14 to 37 kg/ha)—a substantial increase in grazing capacity.

The key data are presented in Table 1, and graphs showing the animal production/stocking rate relationships may be found in Norton's 2003 paper.[9] Daily weight gains were calculated for the stocker cattle only, but stocking rate data were derived from the entire mix of herds. From the graph of production per hectare versus stocking rate,[9] it is clear that the line has not yet reached the point of maximum yield per hectare, the asymptote.

While the Rex Ranch is only one example in a productive ecosystem, it can be used to illustrate the use of strategic rotational grazing to increase animal production.

Research and the Problem of Scale

Scientists can have realistic context or control of variables, but not both (*see Provenza et al., this issue*). Our arguments that paddock subdivision, especially with rotational grazing and high stocking density, can achieve more even distribution of grazing have relied more on logical reasoning and experience than experimental research. That is because the vast body of rotational grazing research has been conducted in small paddocks rather than across landscapes,[8] and in small paddocks all the available forage is equally accessible and uneven distribution of grazing is minimized.[10] Research stations around the world have sustained higher stocking rates than surrounding regions, apparently due to improved grazing distribution in small paddocks, even under continuous grazing.[8] This type of continuous-grazing treatment may represent a landscape of many tiny paddocks, each of which is continuously grazed; but it does not represent a large, complex landscape.

The extensive survey of grazing studies in the 2008 article by Briske and colleagues[11] was reexamined in a literature survey on prescribed grazing carried out for the USDA Natural Resources Conservation Service (NRCS) Rangeland Conservation Effects Assessment Program (CEAP), where none of the cited studies examined time-controlled rotational grazing at a large scale.[12] That second review excluded the possibility that those grazing trials could shed light on solving the problem of uneven grazing distribution: "…constraints

Table 1. Change in production parameters at the Abbot Unit of Rex Ranch near Ashby, Nebraska, as paddock numbers increased and rotational grazing was introduced over a 4-year period. Stocking rate was calculated from all classes of livestock, while daily weight gain was derived from only the stocker class of cattle. Original data supplied by the ranch manager

	1994	1995	1996	1997
Stocking rate (AU/ha)	0.11	0.17	0.20	0.215
Number of paddocks	59	70	85	100
% calving	91.3	94.6	90.7	92.9
Weaning weight (kg)	222	207	210	212
Number of stockers	1300	1350	N/A	2300
Stocker daily gain per ha (kg)	0.59	0.46	0.52	0.49
Stocker daily gain per ha (ha)	14	25	36	37

of experimental research, including the need for relatively homogeneous site conditions necessary for replication and comparison with experimental controls… are unable to—and therefore, do not address livestock distribution in heterogeneous landscapes."[12: p. 29] Briske and his colleagues have recognized the importance of including the human dimension—ranch goals, managerial style and skill, resources, etc.—in future assessments of alternative grazing practices.[11,13]

Few studies have examined the effect of paddock size. At Cedar Mountain, Utah, 70-ha paddocks in 2-paddock deferred rotations were more unevenly grazed than 1- to 4-ha paddocks representing subdivision for 16- to 64-paddock rotational grazing.[10] In the smaller, rotationally grazed paddocks, selection was apparently relatively even across plant species.

The few grazing studies conducted at large scales (e.g., on ranches) have tended to show results opposite to those at small scales, with the most responsive variables tending to be soil parameters, ground cover, and species composition. At the Waggoner Experimental Ranch in northern Texas, in paddocks of 4,400–5,200 acres (1,800–2,100 ha), compared to continuous grazing, an 8-paddock time-controlled rotational grazing treatment resulted in greater basal cover of perennial plants and lower proportions of bare ground.[14] During years of favorable precipitation, these parameters improved at a faster rate in the rotationally grazed paddocks. During drought years, these parameters deteriorated more slowly under rotational grazing.[15]

A few studies have compared larger-scale grazing management units or adjacent full-sized ranches with different grazing management strategies. In New South Wales, Australia, ground cover was significantly higher after 2 years of rotational grazing than under continuous grazing, and species composition became more dominated by palatable plants under rotational grazing, while deteriorating under continuous grazing. In this study, the continuously grazed controls could not sustain the same stocking rates as the rotationally grazed paddocks.[16] In the Flooding Pampas of Argentina, on properties stocked rotationally, bare ground decreased, and cover of desirable forage species and litter increased compared to adjacent properties stocked continuously at the same stocking rate. These properties sustained a 60% higher stocking rate than surrounding properties.[17]

In the Tallgrass Prairie of Texas, adjacent ranches of 3,000–9,900 acres (1,200–4,000 ha), managed with light continuous, heavy continuous, and heavy time-controlled rotational stocking, differed in many soil and vegetation parameters after at least 9 years. Species composition, ground cover, soil aggregate stability, soil penetration resistance, soil organic matter, cation exchange, fungal/bacterial ratio, water-holding capacity, and nutrient availability were all higher, and sediment loss was lower, with time-controlled rotational grazing compared to ranches stocked continuously at the same stocking rate. In most of these parameters the heavily, rotationally stocked ranches were comparable to grazing exclosures because grasses were grazed moderately during the growing season and afforded adequate recovery before being regrazed.[18]

None of the studies described here were included in the Rangeland CEAP literature review.[12]

The accumulated body of small-scale grazing systems research needs to be evaluated in light of the discrepancies with larger-scale studies, and may need to be largely set aside as being of little relevance to this discussion of grazing distribution on commercial ranches. Commercial ranchers operate in extensive, heterogeneous landscapes, where they are confronted with the adverse effects of uneven grazing distribution, and their collective ecological knowledge (*see the case studies highlighted in this issue*) supports the logical reasoning employed in this and other articles in this issue. Similarly, the NRCS policy and advice to ranchers is centered on using multipaddock grazing management. Their personnel are in constant contact with the best conservation ranchers as well as ranchers with rangeland in poor condition, and they fully understand the value of using multipaddock grazing.

Management Implications

The manager has no direct control over incidence, frequency, or magnitude of defoliation of individual plants. This has been confirmed by research studies of rotational grazing at a small scale that demonstrated that frequency of defoliation was not significantly altered by imposing a particular rotational grazing regime, and that an examination of defoliation data would not allow you to infer the combination of grazing and rest periods imposed. In other words, the rotational grazing treatment was not significantly different from the continuous grazing treatment at the animal–plant interface. (See references 8 and 11 for citations that confirm this point.) However, those studies usually involved rotations of only 4 to 12 paddocks, often with multiple cycles per year, where periods of grazing were relatively long and recovery periods fairly short. Intensive grazing management with a higher number of paddocks over a longer cycle incorporating moderate use, short grazing periods, and longer recovery periods could change that story, increasing the influence that managers have over frequency of defoliation.

Although absolute managerial control of defoliation frequency remains elusive, for those plants subject to defoliation we can, however, control the interval between possible defoliation events by manipulating the length of grazing periods and rest periods for an individual paddock. Thus it is possible to control with confidence the minimum period of rest from livestock impacts following defoliation events that might occur within a grazing period, and adjust graze and recovery periods to achieve desirable goals as seasonal conditions vary. There is a danger, however, that by extending the grazing period it is more likely that an individual forage plant will be grazed more than once during that grazing period. When previously grazed plants are grazed again without sufficient recovery, whether within or between grazing periods (*see Steffens et al., this issue*), the pattern of uneven use is exacerbated.[10]

The key to improving distribution of grazing animals is to create smaller paddocks that collectively include areas that were previously neglected or ignored. Rather than stock all small paddocks at the same time for a long time—a managerial nightmare—it is far simpler to amalgamate stock into one large herd that moves from one small paddock to the next in a cycle that covers the entire ranch. Having many smaller paddocks smoothes out the extremes of overgrazing and underutilization that occur in large, conservatively stocked paddocks. Using many smaller paddocks also increases the amount of forage that livestock are likely to encounter as they graze over the entire ranch landscape. We know from small-scale and autecological studies that forage plants require moderate use in the growing season and adequate recovery to thrive and provide high productivity. To do so effectively at the landscape scale requires using many smaller paddocks that facilitate implementing short grazing periods and adequate recovery periods. As conditions change, management on commercial ranches must also adjust to achieve desired goals.

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