Creating rangeland resiliency for stable ecosystems and healthy ranches

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"Do unto those downstream as you would have those upstream do unto you."
– Wendell Berry

Sustainable agriculture has nearly lost its meaning. And perhaps it never quite meant what the word's etymology suggests. "Sustainable" implies continuing, maintaining that which is. Nathan Sayre has shown that the term sustainability may be a tautology, circular reasoning: that which continues is sustainable (Sayre 2005). If what is is healthy, all is well. If the status quo is not good, sustaining it is unhelpful. What most people mean by sustainable agriculture is agriculture that does not rely on non-renewable natural resources, that incorporates regenerative ecological processes. In either term, we must be concerned with identifying and defining that which we are sustaining or generating again.

Value-laden terms like "resiliency", "stable", and "healthy" have natural appeal. But stable doesn't necessarily mean steady-state. And healthy doesn't necessarily mean maximum profit. Current definitions of resiliency include social elements as well as ecological and economic (Sayre et al. 2013; Bestelmeyer and Briske 2012). Restoration science has often treated humans as only the problem. Agriculturalists have rightly reacted to restoration-minded folk who advocate re-wilding, who insist upon returning to an imagined pre-Columbian ecological nirvana that perhaps never existed, or only appeared utopian because the post-Columbus observations were of ecosystems already out of equilibrium because European diseases had recently decimated the indigenous humans; wildlife populations had spiked temporarily as a result of dramatically decreased harvest pressure (Mann 2005). Mounting evidence indicates North American landscapes were anthropogenic well before Europeans arrived. Restoration efforts based on the belief that removing humans from the landscape will automatically cause degraded ecosystems to spring back to a primitive pristine state have no scientific foundation and cause significant human suffering. True resiliency in animal agriculture, especially ranching on natural plant communities, must, by definition, include people in the regeneration equation.

Over the last century, our scientific understanding of semi-arid ecosystems has changed much; changes in understanding have led to changes in management paradigms which support regenerative livestock grazing. As ecological models changed from the steady state or equilibrium model to ecosystem thinking to the non-equilibrium or state-and-transition model, management goals shifted from commodity production (on rangeland) to ecosystem health to socio-ecological resilience. The steady-state model held that ecosystems "want" to return to a climax state, and that left alone they will do just that, like a spring. Under that model, one could define the health of a given ecosystem by its degree of similarity to the climax plant community for a given site, and it was typically assumed that late successional ecological states/plant communities were ideal for the production of the most desired commodity--forage. Rangeland management focused on creating homogeneity through herbicides, planting, fencing, water provisioning, brush control, and prescribed fire to eliminate brush. Disturbances such as fire, flood, drought, and grazing were seen as negative influences and it was generally believed that reducing their frequency or severity or spatial extent would either maintain the proposed climax state or speed return to climax following retrogression (caused by disturbance). Growing recognition that this model didn't reflect reality for nearly all of the semi-arid Western United States, where variability was a more significant ecological driver than aridity, led to thinking in terms of ecosystem services and more recently toward the ecological patterns and processes that support multiple ecosystem services (Fuhlendorf et al. 2012). We will discuss resiliency and rangeland health concepts before relating this to animal nutrition and grazing management.

Resilience has been defined as "the capacity of an system to absorb disturbance and reorganize while undergoing change so as to retain essentially the same function, structure, identity, and feedbacks" (Walker et al. 2004). For those managing land for maximum resiliency, this involves creating or maintaining desirable ecological states and avoiding tipping over a threshold to a less desirable but potentially stable degraded state (Elmqvist et al. 2003). For example, once a sagebrush-bunchgrass plant community has shifted to sagebrush, invasive annual grass, and invasive forbs, removing the persistent excessive disturbances that drove it there will not permit the site to spring back to the desired stable state. It has tipped over a threshold into a new stable state. A resilient system is able to regain a stable state after significant disturbance and is able to resist the loss of a stable state in response to disturbance. The concept "emphasizes the properties of entire socio-ecological systems, rather than the persistence of particular ecological states linked to historical conditions. The term 'resilience' in resilience-based management pertains to societal well-being . . ." (Bestelmeyer and Briske 2012).

Attributes of these ecological models have been summarized by Bestelmeyer and Briske in this table from their 2012 article "Grand Challenges for Resilience-Based Management of Rangelands":

Table 2. Seven distinguishing attributes of steady state, ecosystem, and resilience-based management models (modified from Chapin et al. 2009).

	Steady state management	Ecosystem management	Resilience-based management
Ecological models	Succession–retrogression	State-and-transition, rangeland health	Multiple social-ecological systems/ novel ecosystems
Reference condition	Historic climax plant community	Historic climax plant community, including historical range of variation	Landscapes with maximum options for ecosystem services
Role of humans	Use ecosystems	Part of ecosystems	Direct trajectories of ecosystem change
Ecosystem services	Meat and fiber products	Several ecosystem services	Options for diverse ecosystem services
Management goals	Sustain maximum yield of commodities	Sustain multiple uses	Sustain capacity of social-ecological systems to support human well-being
Science-management linkages	Top-down from management agencies	Top-down from management agencies	Multiscaled social learning institutions
Knowledge systems	Management experience and agricultural experiments	Multidisciplinary science and ecological experiments	Collaborative groups, spatially referenced, updatable database systems

What makes management on rangelands so complex is that rangelands are unusually productive in terms of provisioning services and all are highly valuable. Rangelands are a unique setting that links agriculture and naturally-occurring plant and animal communities. Managers of rangelands recognize the need to accommodate provisioning services such as meat and fiber, regulating services such as soil carbon (which regulates climate) and pollination, cultural services such as recreation and cultural heritage, and ecological support services like plant production, water cycling, nutrient cycling, etc. (Havstad et al. 2007). Recent scholarship has shown that managing for heterogeneity accomplishes all of these and supports profitable ranching; successful ranches are a key component of a resilient socio-ecological system.

There is wide recognition of nearly universal indicators of rangeland health based on the non-equilibrium ecological model (Herrick et al. 2019; Pellant 2000). The 17 indicators described in the interagency technical reference “Interpreting Indicators of Rangeland Health” describe the relative health of three categories of indicators: soil and site stability, hydrologic function (how well a site receives and stores water), and biotic integrity (the health of the plant community). These indicators rank the resiliency of a rangeland site relative to its own potential to maintain the ecological processes of water cycling, energy flow, and nutrient cycling rather than the current botanical similarity to a believed historic plant community or other reference condition.

We now discuss specific links between heterogeneity and ranch profitability. Sam Fuhlendorf argues in a seminal 2012 paper titled “Conservation of pattern and process: developing an alternative paradigm of rangeland management” that livestock production is one service that results from health rangelands, but that it cannot be the driver of all management decisions. Broader ecosystem characteristics such as biodiversity support ranch profitability, however, in several key ways (Fuhlendorf et al. 2012).

Net primary production (NPP) is an important indicator of rangeland health. NPP includes all plants in an ecological site, not just primary forage plants. Botanically diverse rangelands tend to be more productive than depauperate rangelands dominated by invasive annual grasses and shrubs. Diversity is maintained, in part, by not attempting grazing uniformity across all ecological sites, uniformity which promotes a particular suite of plant species tolerant of that particular defoliation timing, frequency, and severity. A mosaic of plant community types and successional stages is promoted through diversity in grazing use patterns. Different plant functional groups and species within functional groups utilize the soil profile differently through a variety of rooting structures, depths, and symbiotic relationships with soil organisms like bacteria and fungi.

Mature research also has shown that plants contain an array of secondary compounds as well as familiar primary compounds such as protein and carbohydrates. These secondary compounds can be anti-quality factors that reduce consumption but many are also beneficial at low concentrations and are sought out by wild and domesticated animals (Provenza 2008; Provenza et al. 2007; Provenza and Villalba 2010). Animals consuming a wide variety of plant species are healthier and require less medical treatment (Provenza et al. 2007). The grazing patterns that promote diverse plant communities permit animals to be selective about what they consume. Research consistently shows that animals consume plants and plant parts that meet their nutritional needs, optimizing animal gain, body condition, and per head profitability. High functional group diversity and species diversity maintains ecological resilience—when disturbance such as drought or variation in precipitation timing occurs different species are expressed in that year. For example, with warmer, drier spring conditions needle-and-thread (Stipa comata) may be abundant rather than Columbia needlegrass.

Plant communities boasting a wide variety of species but dominated by perennials exhibit a broader growth curve because perennials have deeper root systems, facilitating access to soil moisture later into the hot, dry season in the Pacific Northwest. Perennial grasses are important because they are abundant, they stabilize soils, they are often more competitive against invasive exotic plants than shrubs, and they serve vital ecosystem functions (Chambers et al. 2014; Germino, Fisk, and Applestein 2019; Chambers et al. 2016). This has multiple benefits: reduced fire risk, higher forage production, higher forage quality in summer and into fall, resistance to invasive annuals.

Conserving naturally diverse patterns and processes on rangelands requires rethinking grazing management. Fuhlendorf recommends several principles that promote landscape-scale rangeland health:

1. Maintain large continuous tracts of rangelands so that disturbance processes can interact with complex plant communities on a variety of spatial and temporal scales.
2. No single grazing intensity is the right one. A variety of grazing intensities are actually important to conservation of biodiversity.

3. Uniformity of grazing distribution is not the goal of range management. It's too expensive, decreases biodiversity, and inhibits the creation of a mosaic of ecological conditions.
4. "Shifting mosaics are necessary for maintaining ecosystem structure and function and achieving multiple objectives."
5. Rangeland conservation should consider all species of animals and plants.
6. Disturbance regimes (fire, grazing) are vital to ecosystem structure and function. These processes interact with soils and climate to produce biodiversity.

Recent scholarship reinforces the not-so-new idea that adaptive management, including flexible stocking decisions, is the key to grazing management that supports rangeland health and the production of ecological goods and services. A 2018 paper by an all-star researcher team which set out to determine what management strategies on commercial ranches were associated with high rangeland health long-term, i.e., in places where those strategies had been in place for a long time and the ranch's environment would reflect accurately the efficacy of the approach. They found that flexibility, adaptive learning, and aiming for long-term goals were more highly correlated with diverse plant species composition and healthy, diverse wildlife populations than specific grazing management techniques (Wilmer et al. 2018). This flexibility is echoed by others who maintain that stocking rate is still the most influential grazing decision but that there is not a single stocking rate that is "proper".

The future of public lands grazing is with ranchers who are able to manage for non-livestock production goals such as wildlife habitat, clean water, open space, biodiversity. Not coincidentally, these factors also promote ranch profitability and social acceptance. Ranchers stand in better stead with the American public and global citizens than they think (Paul F. Starrs 1998; Brunson and Huntsinger 2008). And the old ways may be the new ways, if large landscapes and cost barriers to extensive infrastructure like miles upon miles of fence lead us back to herding and more direct supervision of grazing herds and flocks of domestic livestock (P. F. Starrs 2018). There is renewed cultural and scientific interest in the merits of herding and transhumance, merits which include animal health, land health, attachment to place, local agricultural economies, and more. Either way, increased understanding of ecological patterns will benefit stock-raising. Producing food and fiber on naturally occurring plant communities where we can also have wildlife habitat, open space, clean air and water is a very good human endeavor and we should pursue doing it well.

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