Pasture Management based on Four Ecosystem Processes

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Do you ever stop to think how simple this business of farming and ranching can be?

There are only four necessary ingredients needed for producing meat, milk, and fiber: Those are carbon dioxide, solar energy, water, and soil minerals. We as humans have worked for centuries to make it increasingly complicated. In the process we have made farming and ranching much more expensive and much less sustainable. All we need to do is look at the few remaining natural ecosystems around the world and the wild animals that come into our backyards.

Natural systems operate just fine without human intervention or costly inputs. The elk and deer produce high quality meat that is tasty and nutritious. The cow elk and white tail doe produce milk and raise their babies. The soil is healthy and the plant community is diverse. Beef, lamb, and dairy production could be just as simple if we bring ourselves back to the idea of four basic ingredients needed to produce our products.

Those four ingredients flow and cycle within our agricultural ecosystems just as they do in natural ecosystems. The only problem is we have screwed up the processes on most of our farms and ranches through our well-intentioned interventions. Much of what we do in our day to day management is counter to healthy ecosystem processes.

What do we mean when we say 'ecosystem processes'? There are four key flows and cycles we should all be aware of and we should build our management strategies around these processes. Solar energy flow involves the capture of carbon dioxide and formation into plants sugars through the process of photosynthesis. Water is a key component in the photosynthetic process as it is drawn from the soil, cycles through the plant, and is released back to the atmosphere as water vapor. Nitrogen and soil minerals are combined with the simple plant sugars to form complex molecules of protein, enzymes, vitamins, and an almost unimaginable array of plant compounds. All of these mineral-containing plant compounds are ultimately consumed by other life forms and the minerals cycle through plants and animals in our ecosystem to ultimately be returned once again to the soil. We need a diverse plant community through the different seasons and across the diverse landscape of our farms and ranches and we need diverse animal life to keep the flows and cycles moving along.

The remainder of this talk deals with the four key ecosystem processes: 1) solar energy flow, 2) water cycle, 3) mineral cycles, and 4) biodiversity.

1) <u>Build a better solar panel</u>: Farming and ranching is really the business of capturing solar energy and turning it into a salable product. Nowhere is this more apparent than in pasture-based agriculture. If you think of every acre you manage as a 43,560 sq-ft solar panel, you easily begin to see how to improve your operation.

First think about what makes an excellent solar panel when it comes to maximizing photosynthesis. It is green growing leaves. Bare soil does not capture solar energy. Dead, brown plants do not capture solar energy. **Only green, growing leaves take solar energy and make it into livestock feed.** If you are using permanent perennial pasture plants, look at how much of the soil surface is covered by green leaves on any day of the year. In an irrigated situation, an excellent pasture should have at least 90% of the ground covered by green growing plants. If you are raising annual pasture crops, think about how many days the soil is left bare during the year or between crops. Timeliness of farming operations and rapid establishment are the key to successful annual pasture crops.

For many farmers and ranchers, the breakdown in the solar panel comes from leaving livestock too long in the same pasture and allowing it to be grazed too short. There are a few key management strategies we can use to increase ground cover in pasture and rangeland. **The first is leave ample post-grazing residual.** This is done far more effectively by managing the time livestock are on a particular grazing unit than by reducing numbers. Reducing numbers only shifts the pattern of patch grazing. It does nothing to improve solar panel effectiveness. **The second strategy is to increase species diversity.** This is best accomplished through varying the season of use so that different species are targeted for grazing while others are allowed recovery in seasons when they were previously targeted. **Providing appropriate recovery periods is the third key.** In a high-rainfall or irrigated environment, the recovery period may be just a few weeks in the peak of the rapid growth season while it might be as long as 60-90 days in slower growth periods. In once-a-year grazing scenarios as we practice in the high desert Idaho environment, providing 14 months recovery rather than 12 months ensures each pasture will not be grazed at the same time of year for several years.

Bare soil means lost production and provides opportunity for weed invasion in both permanent and annual pastures. The most common cause of thin spotty pastures is grazing too short while staying on the same pasture too long. Leaves are the photosynthetic factory of the plant. If excessive grazing removes too many leaves too frequently, the plant cannot support itself and must either reduce its size or die out completely. All across the world, grass farmers lose significant production potential because they keep tearing down their factory. In most of North America, I believe many farmers and ranchers are losing 50% or more of their production potential due to grazing too short and not providing adequate recovery periods. **Key principle is it takes grass to grow grass.**

Letting pastures get over-mature is another significant loss of photosynthetic efficiency on irrigated pastures. While it might seem contradictory for what appear to be two opposite trends (grazing too short vs. pastures getting to tall) to be such significant problems, the two trends often occur in the same pasture side-by-side. An individual blade of grass may only have 3 to 5 weeks of effective solar capture. **Letting perennial plants in a high rainfall environment continue to grow much longer than five weeks without grazing lowers photosynthetic efficiency.** Stockpiling pasture or range for dormant season grazing is the only time we should let pasture plants reach full maturity.

Other tools for keeping your pasture an efficient solar panel include seeding only adapted pasture species, appropriate nutrient management, and timely weed control. **Choose species and varieties that are proven in your environment.** There are very few real wonder grasses. Don't expect a plant developed in a totally different climate to do well on your farm. **Take care of the fertility needs of your pasture to keep green leaves growing vigorously.** Soil testing is a critical tool for pasture management. **Take care of your pastures and weeds will not be a problem.** Remember weeds are opportunists that invade unhealthy pastures. If you do have a weed problem, deal with it promptly by changing the management that created the problem.

2) Capture more of the water that falls on your land: Making more efficient water use should be an objective that graziers think about every day and your daily management decisions should help create an improving water cycle. What are the key factors to be monitoring and what are the adjustments that can be made?

Keeping the ground covered is the number one consideration. Keeping the ground covered entails both the living, growing material as well as the dead plant litter on the soil surface. Obviously, the more new green material you can grow, the better the cover will be and the greater the opportunity to create plant litter. Almost every aspect of the water cycle comes back to this key point.

By leaving taller post-grazing residuals in both perennial and annual pastures, plants grow back more quickly thus creating new cover and leaving more material to ultimately become litter cover. One of the huge benefits of maintaining cover is keeping the soil cooler. Very often in midsummer, the soil temperature at 2" depth can be 20º cooler under sod compared to adjacent bare ground. This greatly reduces evaporative water loss from the soil.

If you use annual pastures and are not already doing so, consider using no-till seedings or interseedings to establish the annuals. Every time the soil is tilled not only does it cause evaporative water loss but it also collapses soil structure resulting in reduced infiltration and increased runoff. Water that leaves your farm as runoff is missed opportunity for growing more pasture. If you follow some fairly basic guidelines, no-till pasture seedings are just as effective as conventional tilled seed beds and come at a much lower equipment and labor costs as well as being much better for the soil and water cycle.

Soils with adequate available nitrogen and mineral content make much more efficient use of water than do soils with chronic nutrient deficiencies. If soil minerals or N is limiting productivity, then each inch of water will give you less forage yield. You can also think about this conversely, applying nutrients as fertilizer, manures, or feeding hay for soil enrichment only pay if you have a healthy water cycle.

Generally I do not advocate the use of iron and oil in grazing management. One of the exceptions I will consider is what is known as keyline plowing. If you have a landscape plagued by fast runoff and water rapidly moving into draws and ravines and flushing out of the system, keyline plowing is a way to correct that problem with mechanical intervention until the natural water

cycle is working more effectively. The most common keyline plow is the Yoeman Plow which is essentially a deep shank ripper. By ripping on what is known as a key line, both surface and subsurface drainage patterns can be altered to give more uniform water distribution across slopes and variable landscape. A key line is the least dropping contour line that allows water to move laterally across a slope rather than vertically downslope. It is a relatively expensive process, but the benefits can be tremendous.

3) Maintain dynamic nitrogen and mineral cycles: Nitrogen is usually considered to the first limiting element for growth in most grassland ecosystems. It is the most mobile nutrient with many pathways for loss so we need to have the N supply in our soil being continuously recharged. From 1950 to late in the 20th century the solution seemed to be just keep pouring on the N fertilizer and all would be well. As we came into the 21st Century, reliance on nitrogen fertilizer to support pasture production was found to be unaffordable as fertilizer cost increased at a much faster rate than the value of our products. Negative effects on biodiversity and nutritional value of forage also emerged. We found N needed to come from somewhere other than a bag.

Establishing and maintaining legumes in pastures is a far more cost effective means of providing N for pasture growth than is fertilizer. Almost all natural grassland systems contain N-fixing legumes. University studies from as diverse environments as Texas to Oregon to Vermont have all shown cost per lb of gain on beef animals to be lower on grass-legume mixtures than grass + N fertilizer pastures. In the 22 years on our farm in Missouri, there were only three occasions that we ever used any N fertilizer. The rest of the time we ran on legume N and an effective N cycle while carrying twice the county average stocking rate.

Almost all legumes thrive in well managed pastures. Lime, phosphorus, potassium, sulfur, and other micronutrients may need to be increased to have legumes prosper, but those tend to be nutrients that will stay put on your farm compared to highly mobile N. A phosphorus molecule applied as fertilizer today may still be working in the same pasture 20 years from now, while the majority of N applied as fertilizer will be gone from your farm in a single season.

As the organic matter content of a soil increases, the pool of N in the soil also increases. Because of the opportunity to lose N through ammonia volatilization from urine, denitrification from microbial processes, and leaching of water through the soil profile, even high organic matter soils still need the regular infusion of new N into the ecosystem.

Minerals through animals with only minimal amounts retained in the animal's body with the majority excreted through either urine or dung. Mobile minerals such as N and K tend to flow predominantly through urine while immobile minerals like P and Ca are found in dung. Mobile nutrients flowing through urine tend to be readily available for plant growth as they are returned to the soil. Because most immobile minerals end up being bound in plant fiber, they are released from the dung only through microbial degradation of the dung pats or pellets. Elements like P can be held unavailable for extended periods of time if the decomposition process is slow.

Decomposition rate of manure is affected by temperature, moisture, microbial life, and degree of disturbance. Because pastures consistently left with taller residuals can maintain better litter cover on the soil surface they tend to remain cooler and wetter which help accelerate decomposition of manure. These same conditions encourage more insect and bird biodiversity which increases the likelihood of physical disturbance of the manure. All of the pieces fit together to help maintain the dynamic mineral cycle.

Biodiversity: Biodiveristy is more than just having several different plant species in your pasture. It refers to the overall breadth of life forms in your ecosystem. We see it most visibly manifested as diversity of plant species and functional groups. In ecological terms, plants perform different roles and functions in the environment. Plants performing similar roles can be grouped into a specific functional group. For example, tall fescue, orchardgrass, and redtop are all perennial cool-season grasses. They grow at a similar time in the and have similar nutrient and water requirements. They are nitrogen users and fibrous rooted. In contrast, red and white clover are perennial cool-season legumes with similar growth requirements. They are quite different from grasses in growth form but also in that they are N-fixers as well as users. Crabgrass and barnyardgrass are warm-season annual grasses so they have different growth requirements and characteristics compared to the two prior groups. Each of these categories of plants form different functional groups. When it comes to diversity in pasture, we want multiple functional groups not just different species.

Here is an example from our pastures in north Missouri describing the species and functional groups present there.

Cool-season perennial grasses	Tall fescue, orchardgrass, timothy, Kentucky bluegrass, red top, quack grass, smooth brome
Cool-season annual grasses	Cheatgrass, downy brome, annual ryegrass
Warm-season perennial grasses	Big bluestem, indiangrass, greasy grass, Florida paspalum, switchgrass,, little bluestem
Warm-season annual grasses	Crabgrass, barnyard grass, yellow foxtail
Cool-season perennial legume	Red clover, white clover, birdsfoot trefoil, black medic, alsike clover, sweet clover, desmodium
Cool-season annual legume	Yellow hop clover
Warm-season annual legume	Common lespedeza
Perennial herbaceous forbs	Tall ironweed, dandelion, goldenrod
Annual herbaceous forbs	Common ragweed, bindweed, morningglory

Microbial, insect, avian, and mammalian diversity will all broaden and increase as plant community becomes increasingly diversified. All of these animal life forms also influence the water and mineral cycles in positive ways. Biodiversity is a reflection on the overall health of all cycles and flows.

Balancing use and recovery in the pasture is one of the strategies we use to enhance the effectiveness of each of the processes we have discussed above. Continuous use of the same area by a set number of livestock for an extended period of time will almost always results in the eventual breakdown of the ecosystem. Nature is a dynamic system and must always ebb and flow. When we begin to too tightly constrain those ebbs and flows, the system fails. Thus the need for balancing use and recovery of the plant and soil communities when we assume management of the ecosystem.

We all know pastures need to be rested to restore CHO storage and plant vigor, but is that all the recovery period provides? **In reality, most forages rely on residual leaf area for regrowth, not stored CHO.** The recovery really is a time allowing new leaves to grow, which in turn supplies excess CHO for storage and helps maintain vigor and root growth. Determining appropriate recovery period length is a challenge graziers face on an ongoing basis. Animal and plant needs must always be balanced. **Longer recovery periods provide healthier plants and ample forage, but reduced forage quality. While shorter recovery periods may supply high quality forage, they may stress plants and also leave forage supply short.** Changing growing conditions dictate recovery periods need to be lengthened or shortened. One thing for sure is leaving more residual increases flexibility in recovery management while lower residual reduces management flexibility.

Soils that are severely trampled during wet conditions recover their tilth much quicker if animal pressure is removed and plant roots begin to rapidly grow back. Allowing adequate recovery period helps reduce soil compaction. A four-year study at the University of Missouri - Forage Systems Research Center found soil bulk density tended to be lower for rotationally grazed pastures compared to continuously grazed pastures for low to medium stocking rates. **At high stocking rates, compaction was equally severe for both grazing management regimes but tended to be less for rotational stocking as recovery periods were extended.**

The required recovery period may be as short as 20 to 25 days in springtime on high natural rainfall or irrigated and fertilized grasses during their peak growth period. The same species may require up to 45-60 days recovery during hotter, drier periods. Recovery requirements for tall grass prairie sites may vary from 30 to 120 days depending on growing conditions. In semi-arid rangelands, a single grazing period per year may be all that is appropriate followed by a full year's recovery. Recovery management cannot be calendar-based, but must be planned in response to growing conditions and planned use patterns.

Complete removal of grazing animals from a grassland ecosystem generally does not result in improved grassland condition. While some short term gains may be seen initially, long term livestock exclusion generally leads to downward trend in grassland condition. This is because grasslands evolved with grazing animals and almost all grass species require some degree of grazing to remain healthy. In a five-year research project in Missouri, we found stocking rates below the recommended level resulted in more rapid deterioration of grassland condition than stocking rates above the recommended range. **To be healthy, grasslands must be utilized.**

Several environmental and wildlife benefits can be attributed to providing planned recovery periods. Both stream bank stability and bird nesting habitat were improved in pasture areas when planned grazing systems were implemented according to research conducted in both Wisconsin and Oregon.

Several studies in the western US have shown notable stream bank improvement where planned grazing systems have been implemented. **It is the continuous presence of livestock in riparian areas that creates problems, not the managed use of a site by livestock.** Native plant species tend to increase when appropriate recovery periods are provided. Appropriateness includes both timing and duration.