Prescription Grazing to Enhance Rangeland Watersheds

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Water is the most precious commodity derived from our rangelands and forests. All these lands should be managed primarily as watersheds and secondarily for their food, forage, wood, wildlife, social, and other products.

Watersheds vary greatly in their natural erosion and flood behavior. In some places plant cover and soil mantle have not developed sufficiently to exert much influence on the way water is yielded from the land. In these places, erosion, sedimentation and flooding is usually high. On more extensive areas, plant cover and soil mantle have developed to exert a high degree of control on the reception and disposition of precipitation. Low rates of erosion, normally moderate peak stream discharges, normally small sediment loads, and optimum infiltration are the result. The key lies in controlling the water that falls on each acre (Bailey 1950).

Depleted watersheds, for whatever reason, cause serious widespread and long-lasting second- and third-order consequences on-site and downstream, economically, and socially. These adversities are intensified under drought conditions.

Formulating prescribed grazing to enhance watershed dynamics requires diagnosis of elements involved.

General

Unpredictable cyclic droughts of varying intensity and longevity are normal occurrences. The old adage "an ounce of preventation is worth a pound of cure" applies to the timeliness of applying a grazing prescription. How grazing is done prior to drought is more important than what can be done effectively after drought has commenced.

The key to grazing that will enhance watershed dynamics is encompassed in the basic ingredients of watershed management, i.e., managing for water efficiency. These ingredients, which have been stated by Barrett (1990), are to CAPTURE, STORE, and SAFELY RELEASE water on watersheds.

Barrett's ingredients do not represent a new concept. Several relatively old studies are cited herein to emphasize that both early and more recent studies related to watershed management are prevalent. There is an urgent need to apply already available watershed management knowledge to the land as a basic ingredient of all renewable resource management.

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Vegetation is only one factor of watershed dynamics. Others include:

— Surface geology	Soft to hard materials
— Soils	Texture, structure, depth, gravel/stone content
— Climate	Frequency, intensity, kind and duration of precipitation, frosts and thaws
— Runoff	High to low peak flows
— Topography	Steep to gentle slopes
— Land use	Intensive to extensive
— Upland erosion	Rills and gullies
— Channel erosion	Banks, bottoms, sediment load

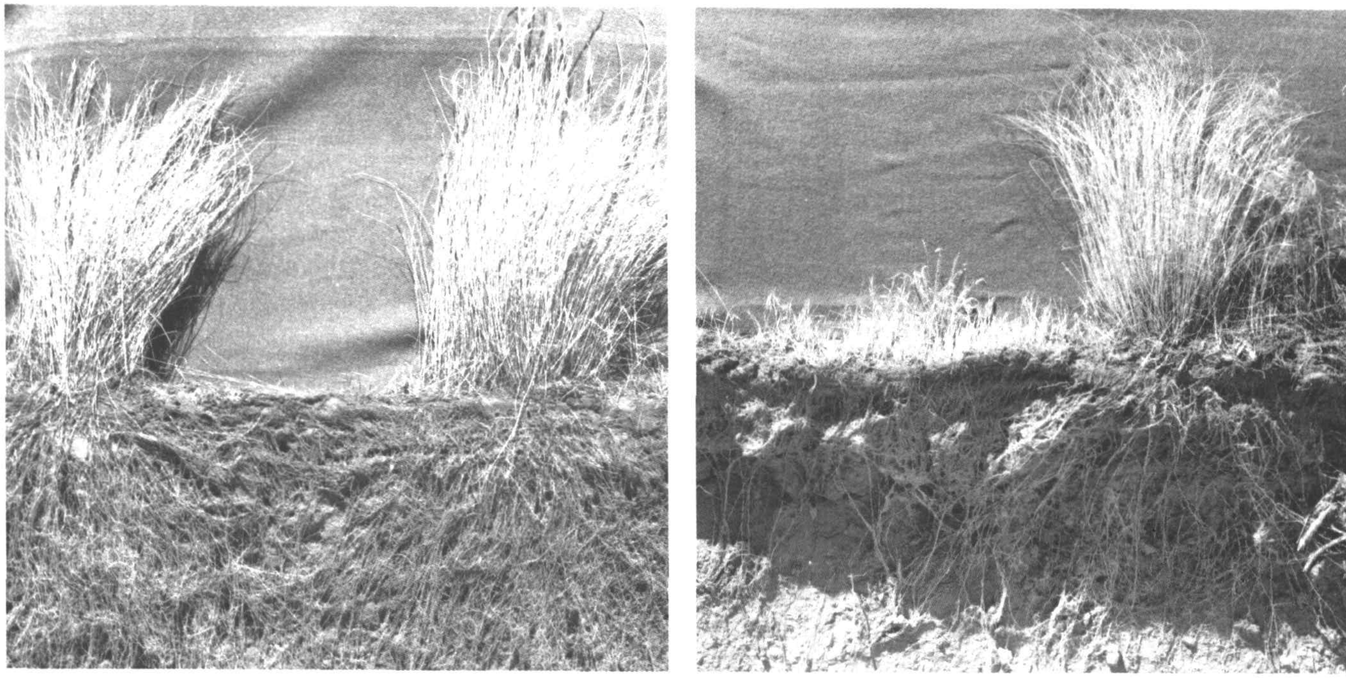
Factors that are responsive to resource management measures are primarily vegetation and surface-soil structure. Depleted organic content, animal trampling and vehicular traffic are causes of soil-structure changes that can be improved over time by resource management. Other factors listed impose restrictions on the degree of feasible improvement that can be achieved through resource management.

The dynamics of woodland and forest watersheds involve vegetational features that are in addition to those related to rangeland watersheds, such as interception of precipitation and insulation from solar radiation caused by trees. The following discussion is focused on rangeland watersheds.

Capture

The role of vegetation in the capture of water on rangeland watersheds is influenced by certain factors which include vegetational type, stand density, size, degree of utilization, and uniformity of total vegetational cover, including residues.

The way *kind* of vegetation influences the capture of water is illustrated by a study that measured the effects of artificial moderate- and high-intensity rainfall on four vegetational types growing on coarse-grained granitic soils in Idaho (Craddock and Pearse, 1938). They reported that based on the general means of each vegetational type, a 35% density wheatgrass-type cover with its fibrous root system absorbed nearly all the water applied. A 25% density cheatgrass-type cover, which is quite dense for that type of vegetation, was moderately effective—75%—for capturing water. A 30% density lupine/needle-grass-



Side-by-side examples—separated by ownership fence and each grazed annually but under different systems—illustrating how a vigorous full stand of fibrous-rooted bunchgrasses provides superior cover, roots, and organic matter in the soil to capture, store and safely release water and create a sponge effect on the watershed.

type cover, which represents early stages of range deterioration at high elevations in the locality of the study, was of little value—50%—for capturing water. The annual weed-type cover with its single-stem tap rooted annuals was regarded only as an erosion hazard with 39% water capture.

One management objective of a prescribed grazing strategy to enhance rangeland watershed dynamics is to improve the proportion of perennial, fibrous-rooted bunchgrasses in the vegetation on the watershed.

Stand density of perennial grass species influences capture of water by physically impeding movement of the water. The greater the stand density of perennial grasses, the slower the water movement over the surface, giving it time to penetrate the soil. The reduced rate of over-the-surface flow also reduces loss of soil and fertility through erosion. This promotes increased vigor, seed production, seedling establishment and, subsequently, stand density.

On a watershed basis, the greater the stand density of perennial grasses, the greater the total amount of water funneled into the below-plant zone and captured.

One management objective of a prescribed grazing strategy to enhance rangeland watershed dynamics is to increase plant vigor. This, in turn, increases the probability and amount of viable seed production. It increases residue cover to benefit micro-environmental conditions necessary for seedling survival which will eventually thicken the stand of perennial grasses.

The way *size* of perennial grasses influences capture of water is illustrated by a study of how individual bunchgrass plants intercept precipitation and funnel water into the soil directly beneath the plant (Ndawula-Senyimba, Brink, and McLean, 1971).

They found that, with 1 inch of precipitation, penetration into bare soil was 4.7 inches. Under a bunchgrass closely clipped to simulate severe utilization, penetration also was 4.7 inches. Under bunchgrasses 12 inches, 16 inches, and 21 inches tall, penetration was 6.0 inches, 6.7 inches, and 7.8 inches, respectively.

This illustrates that water penetration is deeper, or at least more rapid, beneath bunches of grass than under bare soil or severe utilization. From a watershed standpoint, there is a direct relationship between size of grass cover—height and diameter—and depth of water penetration, e.g., volume of water intercepted.

The way *degree of forage utilization* influences capture of water is related to the amount of standing topgrowth left after grazing ceases and, on some soils, to soil compaction due to trampling.

A study of water infiltration as related to degree of utilization was conducted by Rauzi and Hansen (1966). They showed water intake on lightly grazed rangeland to be 2.5 tmes that on heavily grazed and 1.8 times that on moderately grazed rangeland.

A study of soil compaction by animals (Alderfer and Robinson 1947) showed that, in the top 0–1 inch layer, volume weights (bulk densities) were 1.09–1.51 under light grazing and were 1.54–1.92 under heavy grazing. As a soil is compacted, bulk density increases with a corresponding decrease in pore space. This reduces the capacity for storage of water that can percolate through the soil profile to feed plants, springs and streams.

This same study reported that, in the top 0–1 inch layer, non-capillary porosity—the pore space normally occupied by air—was 15% to 33% under light grazing and only 3%-10% under heavy grazing. Such disruption of the normal balance between air, water, organic, and mineral soil composition can be detrimental to biological activities, including plant growth.

One management objective of a prescribed grazing strategy to enhance rangeland watershed dynamics is to practice moderate utilization to maintain a stubble and residue cover. Rotating deferred grazing or rests among management units, as appropriate, avoids grazing the same management unit during the same season in consecutive years, especially during normal wet-soil seasons when soil compaction occurs most readily. Keeping livestock distributed and rotated as frequently as practical avoids localized trampling damage.

Uniformity of vegetational cover, including residues, influences capture of water on rangeland watersheds by minimizing the adverse effects of soil splash caused by impact of raindrops. Raindrops cause soil detachment, which is the first of two stages in the process of water erosion. Transportation of detached soil particles by flowing water is the second stage. Raindrop impact and the resulting soil splash seals the soil surface thereby reducing rate of water infiltration.

Osborn (1950) studied the effects of vegetational cover on reducing effects of soil splash. He reported:

—Uniformity of vegetational cover over the entire watershed is the most important requirement for preventing soil splash and sealing the soil surface. Water lost from certain spots, unless intercepted, is lost from the watershed.

—Effectiveness of the vegetational cover to reduce soil splash is related to the degree of coverage or density and its mass weight or height.

—Best water infiltration occurs on rangeland in top ecological status and progressively declines as status declines. Soil conditions also influence water intake and loss, and these soil conditions are often related to the status of ecological development or deterioration of vegetational cover.

—Soil splash can be controlled on low ecological status rangelands provided surface residues are sufficient to intercept raindrops.

One management objective of a prescribed grazing strategy to enhance rangeland watershed dynamics is to improve the uniformity of vegetational cover and residues over the entire watershed so as to reduce soil splash and minimize spots from which water is lost.

From the standpoint of watershed dynamics, it should be quite apparent that degree of use of the range needs to be judged by the amount of soil-protecting cover remaining, rather than by the percentage of the current season's growth removed, as is too often the customary procedure (Anderson 1960; Anderson and Currier 1973).

Storage

Water is stored in soil in three forms: hygroscopic, capillary, and gravitational. *Hygroscopic* water is that portion of soil water that is held tightly adhered to individual soil grains. It has no movement as a liquid and is not available for biological functions, including plant growth. It is depleted by heat and, once lost, must be fully replaced before water enters other portions of the soil structure.

Capillary water is soil water in excess of the maximum held as hygroscopic water. It lies in the interstices between soil grains. It is in liquid condition but does not respond appreciably to gravity yet it is available for biological functions. When the maximum of both hygroscopic and capillary soil water is reached, this condition is called *maximum field capacity.*

Gravitational water is that soil water in excess of maximum field capacity. It is available for biological functions and is free to move through the soil air spaces to form seeps, springs and creeks. This movement is called *percolation* and it takes place only after the hygroscopic and capillary water storage capacity is attained.

There are many factors which affect storage of water in soil. Those related to soils include surface features such as a sandy mulch or pebble/stone pavement, which affect infiltration and evaporation; texture and stoniness, which affect water holding capacity; structure, which affects infiltration and percolation; and depth, which affects water holding capacity of the soil.

Of these soil factors, only surface characteristics can be influenced by resource management. For example, livestock trampling and vehicular traffic can cause surface compaction on some types of soil, thereby restricting infiltration. Erosion of soils with stony upper layers creates a stone pavement. As soil particles are removed, stones in the upper soil layers are exposed and added to those already on the surface thereby restricting infiltration. Surface stones also occupy space needed for reestablishing a vegetational cover.

One management objective of a prescribed grazing strategy to enhance rangeland watershed dynamics is to minimize impact on the soil surface by livestock and vehicles and to provide adequate vegetational cover to minimize soil splash and subsequent water erosion.

Once water has entered the soil profile, several vegetational factors affect its storage:

—The more height and cover of vegetation, the less water is lost by evaporation due to sun and wind.

—Conversely, the more the vegetational cover, the greater the soil-water loss through transpiration.

—Vegetational residues on the surface reduce water loss caused by evaporation.

—Organic content of the soil increases the amount of water stored in the soil, which enhances the sponge effect of the watershed.

How organic matter increases water storage in soils is illustrated in a study cited by Lyon and Buckman (1934) which compared the water holding capacity of two silt loam textured soils, one containing 1.6% organic matter, the other 4.9%. These soils had maximum field capacities of 39% and 48%, respectively. This represents an increase of 23% in water storage due to increased organic matter in the soil.

One management objective of a prescribed grazing strategy to enhance rangeland watershed dynamics is to increase the volume of roots in the soil profile as well as residues on the surface by improving plant vigor and stand density (Anderson 1951). This, in turn, will eventually optimize soil organic matter and humus in the topsoil.

Safe Release

Safe release of water from rangeland watersheds is needed to benefit on-site vegetation as well as streamflow via percolation.

Prolonging storage of water in the watershed—essentially creating a sponge effect—by reducing rate of deep percolation is an important factor. An optimum stand of vegetational cover utilizes a considerable portion of available soil water rather than allowing it to drain away from the site. For example, a study cited by Lyon and Buckman (1934) compared water loss through percolation from a bare plot versus a vegetated plot on the same soil series under 32 inches precipitation. The bare-soil plot lost 77% of the precipitation through percolation, whereas, the vegetated plot lost 58%.

Excessive percolation or drainage may be much more serious in robbing the soil of plant nutrients than depletion from use of nutrients by vegetation growing on the land. Table 1 illustrates how vegetational cover markedly reduces annual loss of nitrogen, calcium, and potassium by percolation.

Table 1. Average annual loss of nutrients by percolation from bare and cropped soils (from Lyon and Buckman 1934).

Soil	Annual Loss Nitrogen	Annual Loss Calcium	Annual Loss Potassium
	(pounds per acre)		
Dunkirk — bare	69.0	398	72.0
rotation crops	7.8	230	57.7
grass continuously	2.5	260	61.8

Improving seeps, springs, and streamflow involves applying measures that will increase the volume of water captured in the total watershed. Uniformity of treatment over the total watershed is paramount if total volume of water is to be optimized. Water lost from certain spots, unless intercepted, is lost from the watershed.

Prescribed Grazing Strategy

Based on this diagnosis of major ingredients in the CAPTURE, STORE and SAFE RELEASE of water, a grazing strategy designed to enhance watershed dynamics should be based primarily on achieving improved efficiency in the ecosystem involved. Benefits to livestock production, wildlife, aesthetics, and others in the mix of desirable products will follow automatically.

The strategy should include:

—Moderate utilization of forage to build and retain an adequate cover of fibrous-rooted herbaceous species, residues, and soil organic matter.

—Rotation of deferred grazing and/or rests to build root systems and plant vigor to optimize vegetational cover, production and reproduction.

—Pre-conditioning, where appropriate, to benefit plant vigor and improve quality of mature forage for the benefit of wild and domestic grazing animals (Anderson et al. 1990).

—Management practices that will achieve grazing distribution for uniformity in vegetational cover on the watershed.

Intensity of applying this strategy must necessarily vary with the situation involved. In any case however, intensity of application must not exceed the capability of the resources nor the managerial ability of the manager. Otherwise, failure will be inevitable.

No-grazing Option

A logical question to ask regarding a grazing prescription designed to enhance watershed dynamics is whether no grazing at all might be the best prescription. In some instances, theoretically and for a relative short period of years, this may be the preferred option.

However, watershed management should be a long-term endeavor—actually unending—and be based on producing a mix of beneficial products, in addition to water, in perpetuity. Therefore, it is essential to consider other consequences that likely will be involved if the no-grazing option is chosen.

After a period of time, ungrazed herbaceous fibrous-rooted plant species become decadent or stagnant. Annual above-ground growth is markedly reduced in volume and height. Root systems likely respond the same. The result is reduction in essential features of vegetational cover, including the replacement of soil organic matter and surface residues, and optimum capture of precipitation. For example, an unpublished study by Anderson showed the green-leaf weight of a decadent bluebunch wheatgrass plant, which had been ungrazed for a number of years, to be 53% that of a nearby plant having equal basal area and being moderately grazed annually under a rotation of deferred grazing. Both plants at one time were in the same grazing unit until relocation of a highway right-of-way fence isolated one area. Each of the plants measured was typical of the stand of plants on its side of the fence.

Other consequences include (1) loss of quality herbaceous forage for wild herbivores, causing them to move to areas where regrowth following livestock grazing provides succulent forage (Anderson 1989), and (2) increased hazard from wildfires that can be devastating from a rangeland watershed standpoint.

Therefore, it is more realistic, from both a practical and technical standpoint, to employ a livestock grazing strategy that achieves and maintains a healthy, productive and biologically active vegetational cover on the watershed. This is essential for enhanced rangeland watershed dynamics.

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Public Policy on Private Lands—A View From a Professional Society Standpoint

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In representing an organization with diverse membership and a myriad of viewpoints, it is difficult to discuss policy without generalizing, or even waffling. One is almost tempted to join with the oft-quoted legislator who declared, "Some of my friends are for it, and some of my friends are against it; I want you to know that I stand foursquare with my friends."

Actually, if you look at our Society's policy posture at a basic level, we are advocating about the same things for private and public lands. We have been fairly consistent in working for responsible management of rangeland ecosystems for all their resources, based on sound scientific principles and experience. This posture tacitly recognizes two basic facts of life which do not necessarily conflict, but which may complicate implementation of strategy if you lose sight of them. First: there are public interests which are affected by the decisions and actions of private landowners. Second: there are private prerogatives and rights that go with landownership.

How we go about integrating these simply stated truths is going to dictate the degree of success we can expect in getting our basic agenda for scientific conservation and all its benefits implemented. Tom Cowden, an Assistant Secretary of Agriculture for whom I used to do chores, had a homely expression which sums up the dilemma of those who deal with policy in the making and implementation. He said, "The true test of one's sincerity and commitment lies in whether you are willing to put your money where your mouth is." He added, "And when you are as big as the Department of Agriculture, you find you have your mouth in a lot of places."

I want to talk a little bit about some of the implementing strategies that SRM has advocated; but first, you should be aware of the areas in which SRM has felt a need to formally express *its* policy as a step toward perhaps influencing others. These include:

Education—need for professionals with formal scientific training.

Research—need for publicly and privately supported scientific research to serve diverse objectives.

Environmental quality—need to maintain and improve basic resource conditions.

Ecosystem management—sound ecological *and* economic principles as the basis for resource management.

Multiple use of rangeland resources—encouraged on both public and private rangelands. Separate statements on:

- Water management
- Wildlife management (also private land incentives)
- Aesthetic values
- Recreation use
- Livestock grazing

Rangeland inventories—basic to planning and management.

The Society for Range Management has put its money (or at least its efforts) into several activities in attempting to move some of these policies forward.

Cooperative Resource Management has been the subject of grassroots efforts in partnership with NACD and