Texas Agricultural Extension Service

SOUTH TEXAS RANGELANDS

Renovation Practices To Improve Rainfall Effectiveness on Rangeland and Pastures

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With adequate rainfall, rangeland in good condition and recently established pastures can produce large quantities of forage and other desirable vegetation. Excellent production may continue for a number of years; however, forage and desirable plant growth may decrease over time, requiring longer intervals between cuttings or grazing periods for regrowth to occur. Weeds and undesirable plants commonly begin to encroach as the soil's ability to hold moisture declines. These changes in ratios of desirable to undesirable plants frequently result from factors beyond the control of the rancher or farmer. While overgrazing and drought are obvious causes of forage production decline, soil compaction by equipment traffic and livestock trampling is a less obvious cause. Compaction eventually will occur on some soils, even with proper fertilization and resting intervals.

The effective use of rainfall depends on many factors (Fig.1), some of which can be managed to improve the productivity of range and pastureland. Such management can extend grazing periods so that one may be able to avoid supplemental feeding or the leasing of additional land to support the same number of cattle. Such management tools include the mechanical and chemical control of undesirable plants, the use of proper grazing management and soil/sod renovation practices. When properly timed, such practices also will increase the density and productivity of favorable plant stands through improved water infiltration, storage and use.

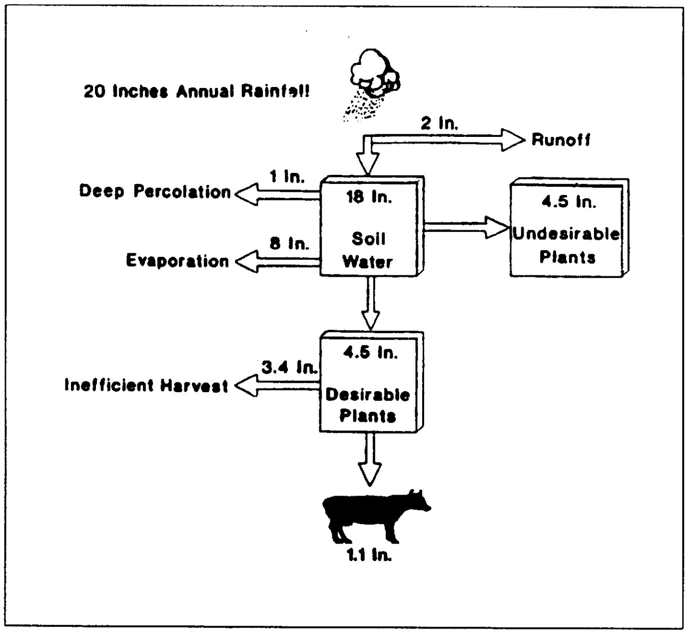

Figure 1. Generalized water pathways and uses on ranges and pastures. (Developed by Allan McGinty et al., 1991.)

Plant/Water Relationships

Plant roots absorb water and nutrients, anchor the plant and store carbohydrates. Food storage is especially important to range and pasture plants because it promotes regrowth after grazing or haying. Roots carry out their function best when in moist, well-structured, non-compacted soil. The looser and more structured a soil, the better the root system is able to enlarge. These soils allow roots to penetrate deeply and extensively, placing roots in greater contact with water and nutrients held by soil particles. As roots elongate into fresh soil, plant nutrients are replenished and moisture moves upward to replenish the root zone, solubulizing additional nutrients from the same soil.

Overgrazing, cutting hay too short and cutting hay just before a dormant period will weaken the plant root systems and may shorten the life of the stand. When less than 50 percent of the leaf area is removed, root systems remain healthy and plants can use soil moisture until very little remains. This ratio

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of leaf matter to root area is necessary to regenerate the food stores necessary to protect plant stands from subsequent stress, and avoids having to build all of the top growth at the expense of food storage reserves. Some leaves must be maintained to collect dew and condense moisture to sustain regrowth. Closely-grazed plants with weakened root systems may permanently wilt when there is still significant moisture in the soil. An adequate amount of leaf area must be maintained in a well-established stand in order to maintain efficient water use.

Soil Water Supply

Water must enter the soil before it can be stored for later use by plants. Rainfall either penetrates the soil surface (infiltration) and moves into the soil profile (percolation), runs off the surface, or pools and is lost to surface evaporation. Under ideal conditions, the soil profile is fully recharged with water and some percolating water passes through the soil to recharge an aquifer. Surface runoff, water infiltration and soil water storage are affected by vegetation, litter and rock cover, soil characteristics, surface crusting, soil texture, slope and rainfall intensity.

How much runoff occurs depends on the vegetation on the site. Good vegetative cover enhances water infiltration because plant growth and residues break the velocity of the rain droplets, thus reducing surface sealing and compaction. Bunchgrass pastures lose very little precipitation as runoff because they have more vegetative cover, standing crop and mulch accumulation. In contrast, sodgrasses provide less soil surface protection (looser, smaller crowns and litter cover) than needed to encourage infiltration. Soil erosion is generally higher on those sites.

Compaction and Hardpans

Root growth (expansion, penetration and distribution) is greatly affected by soil compaction. Compacted soils are very dense and lack sufficient spaces between soil particles to hold air and water. Tight soils prevent the vertical and lateral movement of water within the soil. At the same time they hinder root expansion and penetration, so what little moisture is in the soil is largely unavailable to the plant. Compaction is not visible and is often undetected except through the observed effects of lower production, more undesirable plants, greater surface runoff and increased soil erosion. These restrictions to effective soil water storage and use reduce the effectiveness of sound management practices such as fertilization and overseeding. Compaction can reduce forage production as much as 80 percent.

There are at least three primary types of compaction on range and pastureland: surface traffic compaction; "tillage pans;" and subsurface hardpan layers. Surface compaction results from sustained equipment or livestock traffic, particularly when soils are wet. Most damage is to the upper 2 to 3 inches of soil, and roots have difficulty penetrating the pan. Growth is limited, especially for young seedlings. Such stands of grass will mat on the surface and are prone to stress early in a drought and may fail in an extended drought. Surface compaction is easily corrected because it is shallow and can be broken with a light disking or shallow renovation tool. If corrected early, production may be fully restored within the same growing season.

Tillage pans (hardpans) also restrict root growth and water movement on improved pastures. Tillage pans are caused by repeated implement use at the same depth. This type of compaction is frequently attributed to plow, disk or chisel points and the tractor used to pull this equipment. Soils with restrictive layers have very low permeability rates, seal rapidly, and pack tightly with only basic equipment use. A hardpan is an impermeable barrier to root growth. Since roots cannot grow through the hardpan, they have access only to the moisture and nutrients above the barrier. Soil water below the hardpan cannot move upward to replenish the soil moisture around the root system. Rainfall can saturate the soil only above the hardpan; it cannot move downward to replenish the entire soil profile. As a result, plants have malformed root systems and are very susceptible to drought.

Many natural hardpans have developed over long periods of time as leached minerals and clays are deposited at a specific soil depth. Unless hardpans are broken and thoroughly mixed with porous soil, they have a tendency to reform after a few seasons. Breaking the hardpan is useful only if it allows plant roots to reach moisture at a greater depth.

Renovation Techniques

Compacted soils can be broken with common cultural practices. Most plows will create enough lateral fractures to correct surface compaction. Soil perforators and aerators also fracture the surface while adding multiple pocks and depressions to trap rainfall. Traffic and tillage pans can be easily corrected with deep tillage equipment operating just below the compacted layer.

Chemically altered subsurface hardpans (e.g. calcium carbonate) are generally more difficult to correct. If the hardpan is thin (less than 2 inches and nonuniform), subsoiling may disturb the pan enough to restore water percolation. Thicker layers of impervious soil will soon revert to their former state, sometimes within the same year. While aeration, chiseling and shallow renovation will reduce compaction and increase water storage above the subsurface layer, more aggressive subsoiling is required for subsurface pans (i.e., with a parabolic subsoiler or V-ripper). The paratill plow shatters compaction using a lift/fall principle; it may satisfactorily alter the subsoil, even if for short periods.

Sod renovators, aerators and light chisels can be used to open the soil for water storage without burying or displacing surface litter. As a surface mulch, plant residues improve water infiltration and decrease soil erosion. Of the deep subsoilers, the paratill plow is currently the least destructive to surface residues. The best time to use a subsoiler is when perennial plants are dormant and the soil is moist enough to renovate without clodding, but not so wet as to smear or stick to the equipment.

Renovator points should be placed only 1 inch below the compacted layer. This minimizes the energy costs and horsepower requirements. Perforators, sliding chisels and lifting plows reduce compaction by cutting and creating small displacements of soil, or sometimes by lifting and fracturing entire layers of soil. Frequently, the degree of renovation achieved is directly proportional to the type of equipment used and the horsepower required to pull it. It is important to consider costs and choose renovation equipment correctly. Compacted layers usually can be identified and their depth determined by probing the soil with a smooth steel rod. Equipment can then be leveled and properly adjusted for depth.

Grass Responses to Renovation

During drought, it has been observed that grasses on renovated land continue production and remain green 2 to 3 weeks later than grasses on compacted soils. Likewise, the nutrient quality of the forage is higher. In field tests, yields of Coastal bermudagrass, buffelgrass and kleingrass increased 100 to 300 percent over various periods of evaluation (Table 1). Four years after renovation, forage differences between renovated and non-renovated clay soils were negligible. Deep renovation of a loose soil with no compaction layers does not increase vegetation, however.

Renovation Equipment

Several methods can be used to renovate ranges and pastures and increase water use efficiency. These include plowing, deep subsoiling, chiseling, disking and aeration.

Plowing

The strong points of the moldboard, or turning plow, center on its ability to completely invert the plowed layer of soil. It is useful to plow before applying fertilizers and herbicides. Plowing buries weeds and incorporates important residues such as animal manures and legume crops. The turning action of the plow almost completely fractures the root zone, removes most compaction and reduces weeds to a manageable level.

There are disadvantages to moldboard plowing, however. One is that the loss of surface residue increases the risk of erosion. Also, the design of the plow tip and "slide" create compaction just below the point. Not much lifting action takes place since gangs of plows usually are pulled under their own weight. Thus, plowing at the same depth for several years creates subsurface compaction that restricts root growth and subsurface water movement. In the past it was believed that the best way to eliminate such compaction was to plow at ever greater depths. However, once shallow soils have severely eroded and most of the topsoil is gone, plowing simply brings up and incorporates undesirable (acidic, poorly structured or sterile) subsoil material into the root zone. Sometimes deeper tillage is not possible because of buried rock, caliche outcrops or high equipment power requirements.

Table 1. Average annual weights of additional forage (air dried) obtained with different renovation tools in South Texas, 1986-1992.

Renovation tool[1]	Forage yields (lbs./a) Over non-treated pastures: Coastal bermudagrass	Kleingrass	Buffelgrass
Subsoil	2,026		1,167
Plow	2,266		711
Chisel	1,412	3,539	1,275
Disc	751		2,059
Aerator	1,000		3,864

[1]Representative tools are listed to illustrate typical advantages from renovation; duration of these studies varied; tool types are grouped into similar categories.

Subsoiling

The first subsoilers were functional, but were relatively awkward, power intensive and highly disruptive to the field surface. These subsoilers created large clods which required disking and surface leveling before routine forage production could be resumed. Even today, many subsoilers create large clods so that subsequent leveling is necessary before haying equipment can move safely over the land. Frequently subsoiling uncovers large rocks, buried wood and other materials hazardous to plows.

Because of the excessive power requirements for subsoiling (deep tillage) and the potential for undesirable surface roughness, the best time to do it is in winter when grass is partially or totally dormant and the soil is more likely to be moist. This may not be important for pastures or rangeland being totally reestablished, but it is important to the renovation of old rangeland sites and hayfields.

Subsoiler legs or shanks can fracture compacted soil layers and produce smaller clods and less upheaval if the soil is neither too wet nor too dry. The land surface can be restored to acceptable smoothness with one, or perhaps two, diskings. Poor equipment design and minimum lift sometimes create additional compaction at a deeper level, but this is not as critical to water storage. Structural damage is possible if soil is too wet. The engineering of subsoilers and subsoiling plows has evolved to include coulters and lifting points, which has reduced surface roughness (Figure 2).

Subsoiling is easiest when a pasture is being reestablished and saving surface

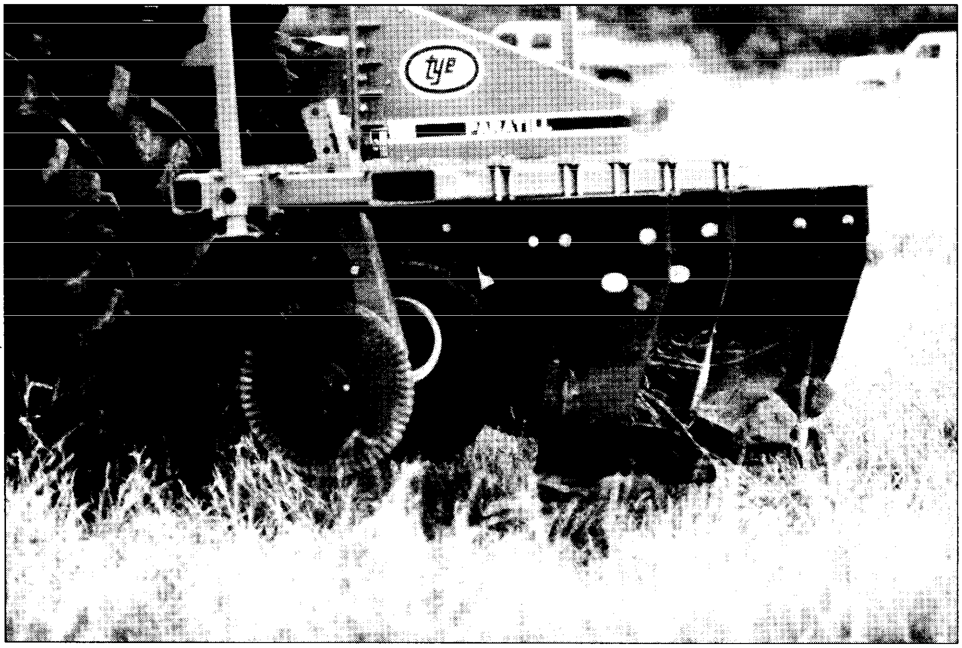

Figure 2. Subsoiling breaks compaction layers to allow better plant root penetration and water percolation through the soil.

plants and seed from burial is not an issue. Subsoiling is important to sustained forage production. All surface equipment and livestock ultimately create compaction and the need for subsoiling is inevitable under most intensive agricultural production systems.

Chiseling

Chiseling is accomplished by dragging shanks, with or without blades, in the soil at various depths and spacings. Chiseling usually is shallower than subsoiling. Typically, shanks are on 24- to 36-inch spacings and are inserted 4 to 12 inches into the soil. Chiseling is a faster process than plowing, leaves residue on the surface between shanks, and can be used to break deeper compaction areas if required. Since sod and residues are left between shank rows, there is still adequate erosion protection. Chiseling can be used for sod and some hardy bunch grasses. Chiseling does leave the surface fairly rough, so a followup disk harrowing or dragging may be required (Figure 3).

Figure 3. Chisels pull shanks through the soil at various depths to fracture hard pans and compaction layers.

Disking

The farm disc is commonly used on pastures to break up surface compaction to a depth of 4 to 5 inches. However, heavier discs (1,500 pounds of weight per running foot) with 36-inch blades are often used for brush management and seedbed preparation on rangeland (Figure 4). These heavy discs renovate soil to a depth of 12 to 18 inches, promote water infiltration and, ultimately, improve grass production. It is best to disk in late winter, before peak rainfall and the beginning of spring growth. Repeatedly disking at the same depth may also cause hard pan development.

Aeration

Aerators use knives, blades, spikes or cleats to create pocks or cut furrows in the soil. This fractures surface crusts and compaction layers (Figure 5). Aeration loosens soil, increases the space between particles and increases water and air movement.

Summary

Many rangelands and pastures with undesirable soil and vegetation characteristics have such low water storage capacities that plant stress is inevitable when rains do not occur frequently. Renovation may be necessary to eliminate compaction layers and plowpans or to loosen the soil at specified levels in the profile. Renovation increases the penetration of water into the soil profile, decreases surface runoff, aerates the soil for better root development and gas exchange, and ultimately increases plant production. Renovation practices must be carefully planned and integrated into the total ranching management system.

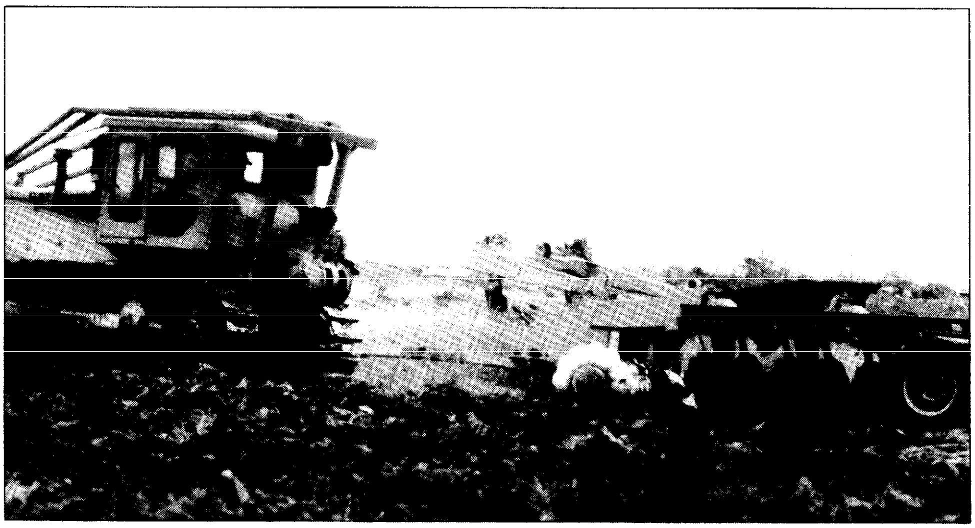

Figure 4. Disking breaks up surface crusting.

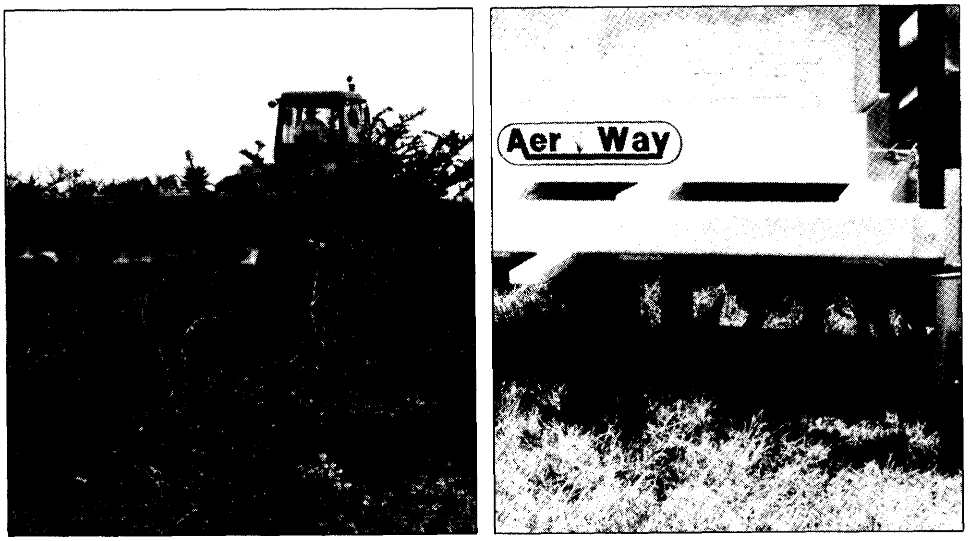

Figure 5. Pasture aeration allows water and nutrients to infiltrate the soil.

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Additional Readings

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