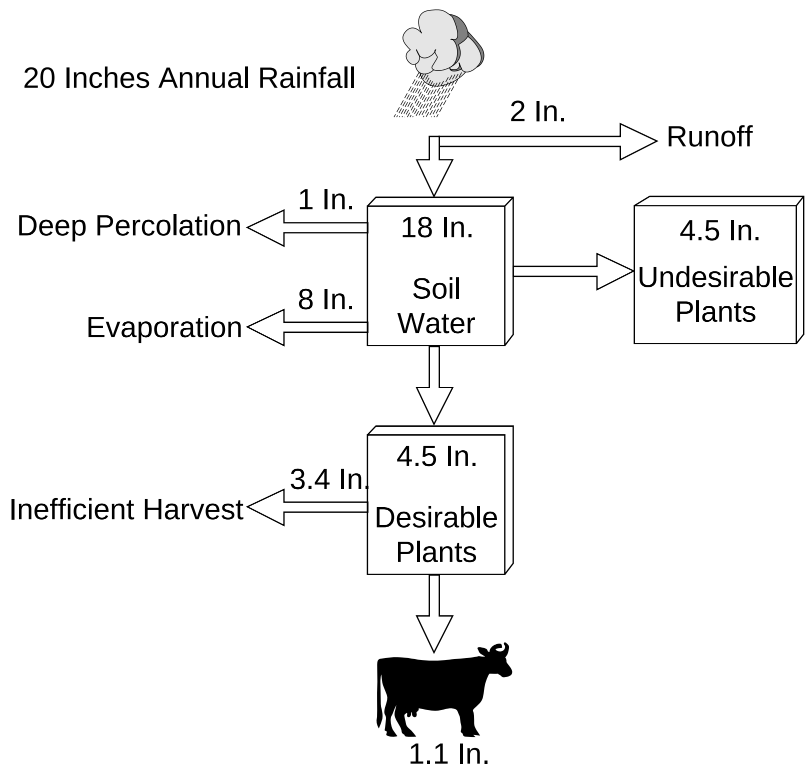

Figure 1. Conceptual model of water use on rangeland. In this example, only 1.1 inches of annual precipitation are used to produce forage that is actually consumed by livestock.

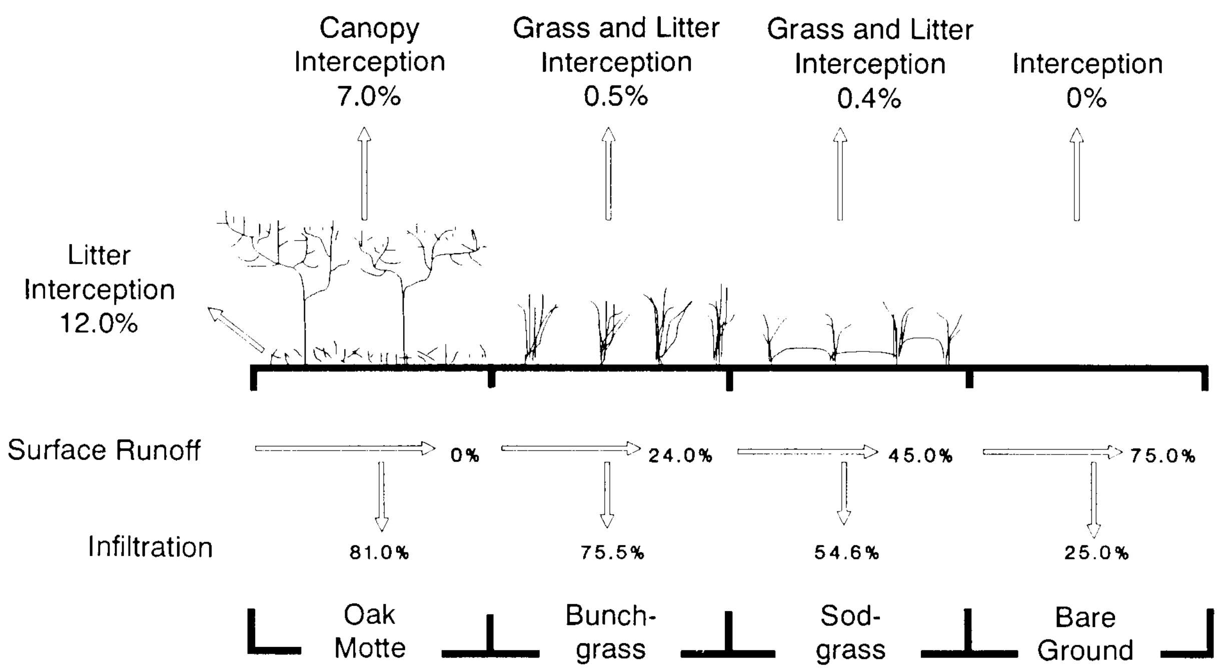

Figure 2. Interception, infiltration and runoff from oak, bunchgrass and sodgrass dominated areas located at the Texas Agricultural Experiment Station, Sonora. This is based on 4 inches of rainfall in 30 minutes (Blackburn, et al., 1986).

soil color, plant cover and season of the year. The estimated percentage of annual precipitation loss via evaporation from the soil surface and plant canopies (Figure 1) can be expected to increase in the more arid regions of the state.

Deep percolation below the root zone does not usually represent a major loss of rainfall. Figure 1 estimates this value at 1 inch or 5 percent of annual rainfall received. Research in the Texas Rolling Plains has determined deep percolation losses vary from 0.5 percent to 1.4 percent of total annual precipitation depending on the type of vegetation cover (Carlson, et al., 1990). Significant loss is only likely on rangelands dominated by sandy soils or sites with very shallow soils overlying a fractured rock substrate.

Not all plants in any given pasture are desirable for livestock or wildlife production. Undesirable plants such as brush or toxic and/or noxious weeds, deplete water that could be used by more desirable species. In Figure 1, unwanted weeds and brush were estimated to use 4.5 inches of water per year (assuming 20 inches annual precipitation). However, this will vary greatly depending on undesirable plant density and species.

Rangelands rely on perennial vegetation to produce stable supplies of nutritious forage from year to year. Therefore, grazing use must be controlled to leave sufficient forage for future growth and reproduction of desirable species. Research indicates that the proper use of rangeland will result in approximately a 25 percent harvest of the annual forage production by livestock. The other 75 percent is left for regrowth or is lost through trampling, weathering or consumption by insects or small mammals such as rabbits. Thus, of the 4.5 inches of annual rainfall utilized by desirable forage plants, only 1.1 inches (25 percent) will be used to produce forage that is actually consumed by domestic grazing animals (Figure 1). This equates to an approximate overall water use efficiency of 5 percent for livestock production.

Managing to Improve Rainfall Effectiveness

Management can improve the effectiveness of rainfall by reducing runoff, evaporation and undesirable plant use of water, as well as improving the forage harvest efficiency of livestock.

Reducing Runoff

Surface runoff can represent a serious loss of water from the ranch, resulting in significantly less sustainable forage production for livestock and/or wildlife. The erosive nature of runoff transports soil nutrients from the site. When erosion is severe, soil depth is reduced, which reduces the amount of water that can be stored in the soil profile. Reduced water storage within the soil profile results in the plants running out of water faster, thus increasing the frequency and severity of drought. Management can reduce runoff through manipulation of pasture vegetation.

Research has shown that rangeland infiltration rates generally increase as total plant cover increases (Figure 3). Plant cover slows water movement across the soil surface, allowing more time for water to infiltrate before being lost down creeks and draws. Plant cover also protects the soil surface from rain drop splash. When raindrops hit unprotected soil surfaces, they tend to destroy soil structure, resulting in the pore spaces sealing and crusts forming. Stable soil pores allow water to move into the soil. Finally, plant cover provides organic matter to the soil, which maintains soil structure and aggregate stability, both of which positively influence rainfall infiltration rates.

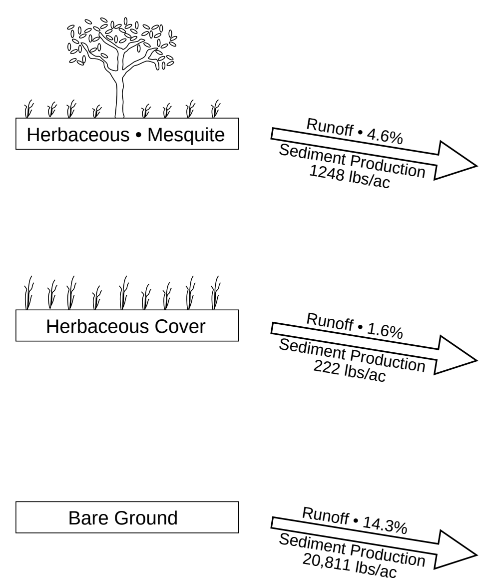

Figure 3. Water intake rate compared to total vegetal cover and soil structure in the northern and central plains (Adapted from Rauzl et al., 1968).

The type of vegetation present also affects runoff. Research at the Sonora Agricultural Experiment Station has shown that bunchgrasses are more effective at reducing runoff than sodgrasses. Oak mottes produced less runoff than either sod or bunchgrasses (Figure 2). Livestock stocking rates, grazing systems and species of livestock represent the major management tools for manipulation of the range forage base.

Trampling by grazing animals also affects the soil surface, which in turn affects runoff. A commonly asserted hypothesis is that runoff can be reduced by utilizing high densities of livestock for short periods of time to intensely trample the soil surface. However, research conducted does not support this hypothesis. Studies generally show livestock trampling increases soil compaction, disrupts soil structure and stability of water stable soil pores and destroys cover provided by algae, moss and lichens. These negative impacts tend to increase as stocking intensity increases, resulting in increased runoff loss.

Reducing Evaporation

Much of the evaporative losses of rainfall occurs following low intensity rainfall events. On Texas rangelands, rainfall amounts of less than 0.5 inch are common. Evaporation losses can be reduced by maintaining sufficient plant cover to shade the soil surface. Shade lowers soil temperatures while the plant itself buffers the impact of wind across the soil surface.

Management of the forage base can also reduce evaporation by manipulation of plant canopy interception. Dense woody plant and litter cover has the potential to intercept high percentages of rainfall, especially when rainfall amounts are low. Plant communities dominated by grasses intercept and evaporate back into the atmosphere a much lower percentage of rainfall (Figure 2).

Reducing Undesirable Weed and Brush Density

Not all plants in a pasture contribute toward livestock or wildlife production. Undesirable plants compete directly with more desirable range forage plants for limited supplies of water. For example, it has been estimated that mesquite uses approximately 800 pounds (100 gallons) of water for each pound of above ground plant growth produced (Nilsen, et al., 1983). Saltcedar, an aggressive woody invader of moist pastures, rangelands and riparian habitats can use from 0.1 to 0.4 inch of water per day and from 48 to 156 inches of water per year (Davenport, et al., 1982). Perennial grasses are generally more efficient users of water, requiring from 300 to 600 pounds (40 to 75 gallons) of water for each pound of above-ground biomass produced (Black, 1971).

Infiltration rates under dense woody plant canopies can be very high (Figure 2), with little rainfall reaching the soil surface being lost as runoff. These areas are also capable of capturing significant quantities of water running off adjacent areas with poor plant cover. Thus, dense woody thickets can capture and use more water than they receive directly from precipitation, while the reverse is true for adjacent areas dominated by bare ground or sodgrasses. Therefore, because the soil beneath woody plants can absorb water more rapidly than adjacent grass sites, woody plants can have a significant competitive advantage over more desirable grasses and forbs.

The actual percentage of water used by unwanted plants will vary greatly from ranch to ranch depending on the species of plants present and their density. Implementation of weed and brush control practices may be necessary to reduce undesirable plant densities so that the efficiency of water use for livestock or wildlife production can be improved.

Improving Forage Harvest Efficiency

Livestock harvest of vegetation must be limited to ensure regrowth and reproduction of perennial range vegetation. As a rule of thumb, if a site is capable of producing 1,000 pounds of forage per year, one-half (500 pounds) must be left to ensure the continued health and productivity of the forage base. Of the one-half reserved for grazing, 50 percent (250 pounds) will be lost to trampling, weathering or consumption by insects and small mammals. Only 25 percent (250 pounds) is actually consumed by livestock.

The grazing of multiple species of livestock and/or wildlife represents one of the most effective methods to improve forage harvest efficiency on rangeland. Diet selection differences between the various species of grazing animals allows more even utilization of the entire forage base, without over utilization of any one part. Grazing systems, fences, location of livestock water as well as feed and salt placement can all be used to improve grazing distribution. When improving forage harvest efficiency through grazing, sufficient plant and litter cover must always be maintained to ensure infiltration of precipitation into the soil profile without undue loss of water through runoff.

Reducing Soil Erosion

Soil resources must be protected to ensure sustainable, long-term use of rangeland. The soil profile serves as the storage reservoir for all rainfall received. Loss of soil through erosion reduces the quantity of water that can be stored at any one time. It also diminishes the ability to produce the proper plant cover to optimize infiltration rates. Many soil and vegetation factors interact to influence soil erosion (Table 1). In general, management that maintains adequate plant and litter cover on the soil surface will reduce erosion to minimal levels (Figure 4).

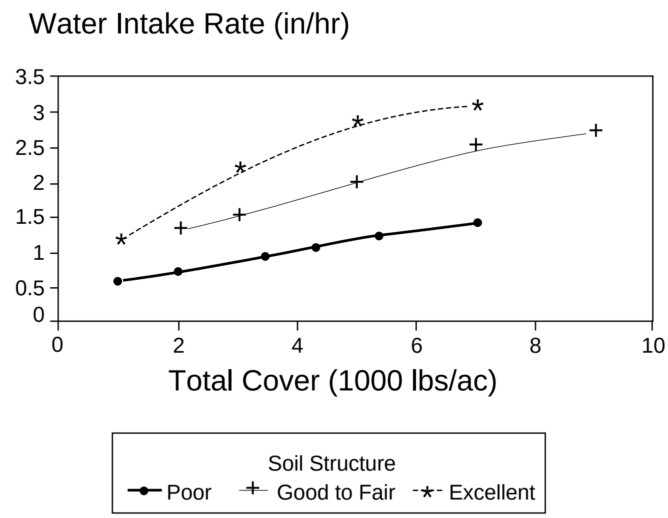

Figure 4. Runoff and sediment production are shown from rangeland dominated by bare ground (poor), herbaceous vegetation (good to fair) or herbaceous vegetation plus mesquite (excellent) (adapted from Carlson et al., 1990).

Summary

Rainfall represents the single most limiting factor to livestock production from Texas rangelands. Although management cannot be used to improve the amount or predictability of rainfall received, management can improve rainfall effectiveness by increasing rainfall infiltration rates, reducing evaporation from soil and plant surfaces, controlling soil erosion, reducing noxious/toxic plant densities and improving forage harvest efficiencies.

Table 1. Summary of relationships between sediment yield and watershed components (Adapted from Blackburn, et. al. 1986).

Watershed Component	Sediment Yield
As runoff increases	Increases
As bare ground increases	Increases
As bulk density increases	Increases
As soil moisture increases	Increases
As grazing pressure increases	Increases
As rock cover increases	Neutral
As vegetation cover increases	Decreases
As litter cover increases	Decreases
As standing crop increases	Decreases
As surface roughness increases	Decreases
As soil depth increases	Decreases
As organic matter increases	Decreases
As aggregate stability increases	Decreases

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