



Grazing Management and the Environment

Larry A. Redmon

State Extension Forage Specialist, College Station

The Federal Water Pollution Control Act, commonly referred to as the Clean Water Act (CWA) was passed in 1972 and amended in 1977, and is the foundation for surface water quality protection in the U.S. The Act is designed to restore and maintain the chemical, physical, and biological characteristics of the nation's waters. The Act also requires states to set standards for surface water quality and regulate wastewater discharges. The Environmental Protection Agency (EPA), which has oversight of the CWA, has "delegated" responsibility for the CWA to the Texas State Soil and Water Conservation Board (TSSWCB) and the Texas Commission on Environmental Quality (TCEQ). The TSSWCB has responsibility for agricultural *nonpoint source* pollution oversight. *Nonpoint source* pollution originates from multiple locations and is carried primarily by precipitation runoff. The TCEQ has responsibility for *point source* pollution and urban and other *nonpoint source* oversight. The difference in *non-point* source pollution and pollution from *point sources* is that point source pollution can be traced to a specific location and point of discharge.

According to the EPA (2008), under section 303(d) of the Clean Water Act, states, territories, and authorized tribes are required to develop lists of impaired waterbodies. These are waters that do not comply with the water quality standards set by states, territories, or authorized tribes. The law requires the development of Total Maximum Daily Loads (TMDLs) for these waters. A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards. The TCEQ is responsible for implementation of specific TMDLs in Texas and says (2008) that the TMDL defines an environmental target and, based on that target, the state develops an implementation plan to mitigate anthropogenic (human-caused) sources of pollution within the watershed and restore full use of the water body. According to the *DRAFT 2008 Water Quality Inventory and 303(d) List*, 386 water bodies are impaired in Texas (Fig. 1). Of these, approximately half of the impairments are due to excessive bacteria. As

of the date of this writing, there have been 110 TMDLs for 69 water bodies implemented in Texas.

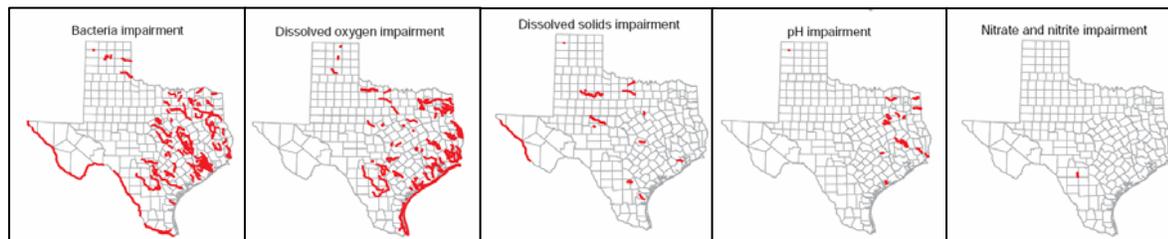


Figure 1. Water bodies in Texas experiencing quality impairments for various reasons according to TCEQ, 2008.

While studies have indicated that livestock can contribute to bacteria loading in waterbodies, livestock have been produced for centuries around the world and are grazed on both rangeland and introduced forage pastures. Management strategies are generally different between the two systems due to environment, soil type, relief, and the fact that fertilizer is a common input associated with introduced forage production systems. Rangelands are natural systems managed by ecological principles, while pastures are usually managed according to agronomic principles with cultural inputs. While abuses have occurred in the past that degraded forage and soil resources, current best management practices seek to optimize livestock production in a manner that protects and/or enhances the environment in which the livestock are produced. The following discussion illustrates those aspects of production that should be addressed to reduce negative impacts on the environment and best management practices (BMPs) for minimizing those negative impacts.

THE IMPORTANCE OF GROUND COVER

It is critical to maintain an appropriate level of ground cover on grazing units. The amount of ground cover directly affects the level of soil erosion, water capture or loss from the site, plant vigor and persistence, and animal performance. Each of these topics will be addressed in the following sections.

SOILS

Soil Erosion Due to Water: Accelerated soil erosion begins with raindrop impact (Fig. 2), and the effects are much ameliorated by ground cover. A raindrop impacting bare ground dislodges soil particles, destroys soil structure, and the splash can cause an appreciable transportation of the soil (Brady 1990, Branson et al. 1981). Soil particles dislodged by raindrop

impact can then be held in suspension and transported off site via overland flow (runoff). Dislodged particles also seal the soil surface by plugging micropores.

This sealing action reduces water infiltration rates and increases runoff. Raindrops striking ground cover, however, are intercepted by the plant canopy, which absorbs impact energy and protects the integrity of the soil surface. The energy of the runoff water is likewise diminished by ground cover, thus reducing erosion (Fig. 2). Precipitation intercepted by ground cover canopy is also subject to evaporation. This can be positive or negative depending on the moisture balance of the soil profile.

After a raindrop makes impact, it is subject to three fates: it can infiltrate the soil, evaporate, or become a part of runoff (Holechek et al. 1998). Infiltration (movement into the soil) is primarily determined by soil texture. Fine-textured soils such as clays generally have low infiltration rates, and slow percolation (movement through the soil) rates. Coarse-textured soils, such as sands, usually have high infiltration and percolation rates. Runoff occurs when precipitation rates exceed infiltration rates of the soil. Soil loss (erosion) then occurs due to detachment and transport of soil particles from the site. Loss of soil particles can be somewhat

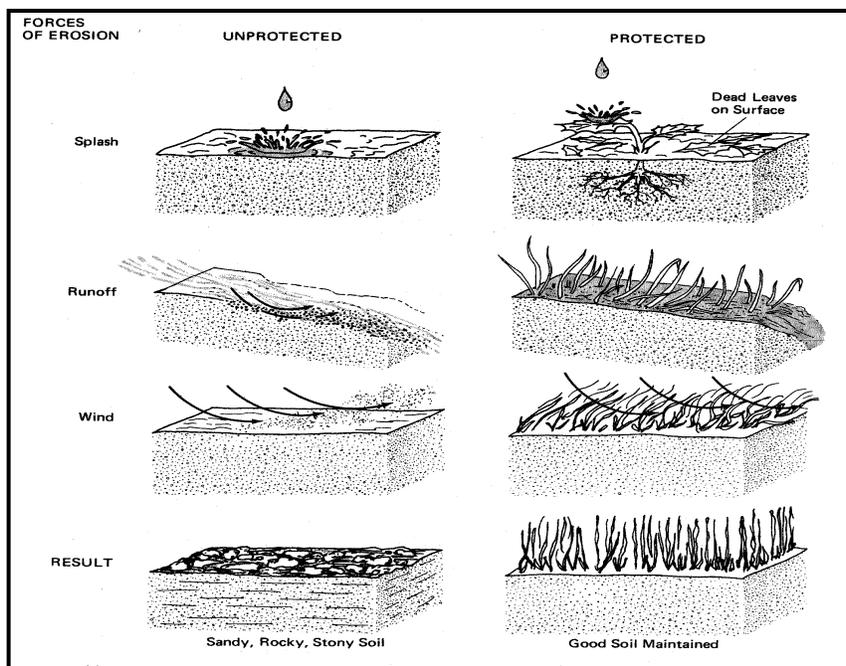


Figure 2. Vegetation effects on reducing soil erosion. (From Nebel 1981 as used by Holechek et al. 1998)

uniform in nature (*sheet* or *interrill* erosion). Extreme interrill erosion is apparent when soil pedestals are created by erosion around an area covered by material resistant to raindrop impact, such as rock. The fact the surrounded soil is eroded without undercutting the soil under the resistant material illustrates the highly erosive nature of raindrop impact (Thurrow

1991). Further erosion results in creation of small, distinct flow paths that can be corrected with

tillage (*rill* erosion). Erosion that continues unabated becomes severe enough tillage cannot repair the damage to the site and vehicles cannot traverse the deepened channel (*gully* erosion). Stream bank erosion is defined as soil displaced from banks of rivers or streams. Besides loss of essential topsoil, erosion also causes valuable soil nutrients such as N, P, and K to be lost from the site with the potential for contamination of water sources.

Overstocked rangeland and introduced-forage pastures reduce the quantity of ground cover. Reduced ground cover in turn increases sediment production, decreases water quality, and reduces the capacity of surface water storage reservoirs. The use of proper stocking rates on rangeland and introduced-forage pastures maintains adequate permanent ground cover and reduces soil erosion potential, and thereby serves to maintain water quality and reservoir capacity.

PLANT PERSISTENCE AND VIGOR

Forage Production: Too heavy a stocking rate places excessive grazing pressure on forage resources. On either rangeland or introduced-forage pastures, heavy grazing pressure of desirable plants decreases forage plant vigor and reduces plant persistence. Moderate utilization of forage plants usually does not reduce root production. Beyond about 50% utilization of the aboveground production, however, results in a concomitant reduction in root development (Fig. 3). Over-utilization decreases the amount of photosynthetic material remaining for the plant. Decreased photosynthesis has a negative feedback causing a reduction in root development,

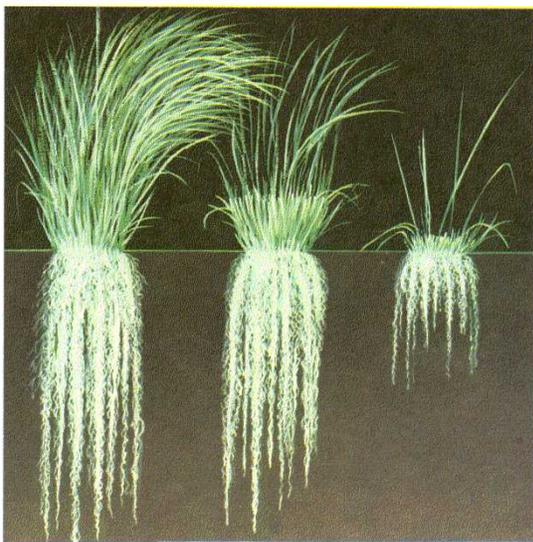


Figure 3. Effect of over-utilization of forage plants on root production.

which in turn reduces the amount of moisture and soil nutrients that may be taken up for plant production. The long-term result of this situation is a reduction in plant vigor, plant frequency and abundance, and an increase in bare ground. Plant species composition shifts as an invasion of less desirable or undesirable species occurs.

This species composition change is referred to as an overgrazed condition and leads to a degradation of range introduced-forage pasture condition. Under these conditions, if the stocking

rate is not reduced, carrying capacity is diminished, animal performance is decreased, and the potential for profit eliminated. Input costs (increased herbicide use, increased winter feeding costs) associated with the livestock production enterprise are increased, thus making a bad situation worse.

Water Conservation: Maintaining adequate perennial ground cover has a direct impact on how much precipitation is captured on-site versus how much is lost as runoff. Due to overstocking and over-utilization of more desirable forage species, earlier seral stage plant species increase in abundance and generally do not provide the type of ground cover required to reduce runoff rates and increase infiltration rates. On rangelands and introduced-forage pastures stocked at the appropriate rate, however, healthy stands of forage significantly reduce the velocity of overland flow of water during precipitation events allowing water to infiltrate the soil for use by plants or for recharge of groundwater aquifers. On overstocked sites, there is little forage to impede overland flow of precipitation. Subsequently, much of the precipitation is lost from the site, thus reducing forage production potential (Fig. 4). Overstocked pastures can also experience soil compaction of the more clayey soils. This can lead to further reduction in infiltration rates and increases in overland flow.

Holechek et al. (1998) cite numerous studies indicating a reduction in infiltration rates associated with heavy stocking rates. Holechek et al. (1998) went on to summarize Gifford and Hawkins' (1978) work with the following statements:

- 1) Ungrazed plots have higher infiltration rates than those of grazed plots.
- 2) Moderate and light grazing intensities have similar infiltration rates.
- 3) Heavy grazing causes definite reductions in infiltration rates over moderate and light grazing intensities.

ANIMAL PERFORMANCE

Stocking Rate: The most critical aspect of livestock production that is under direct control of the manager is the use of the appropriate stocking rate. Redmon and Bidwell (1997) have stated that no other single management practice has a greater effect on the sustainability of a livestock production enterprise. Stocking rate is defined as the relationship between the number of animals and the grazing management unit utilized over a specified time period. Stated more simply, it is the number of acres required per animal unit for the grazing season that can be sustained on a long-term basis without forage or soil resource degradation. A moderate stocking

rate provides a good balance between plant and animal performance while maintaining adequate vegetative cover to protect soil resources. Although moderate stocking rate will be different

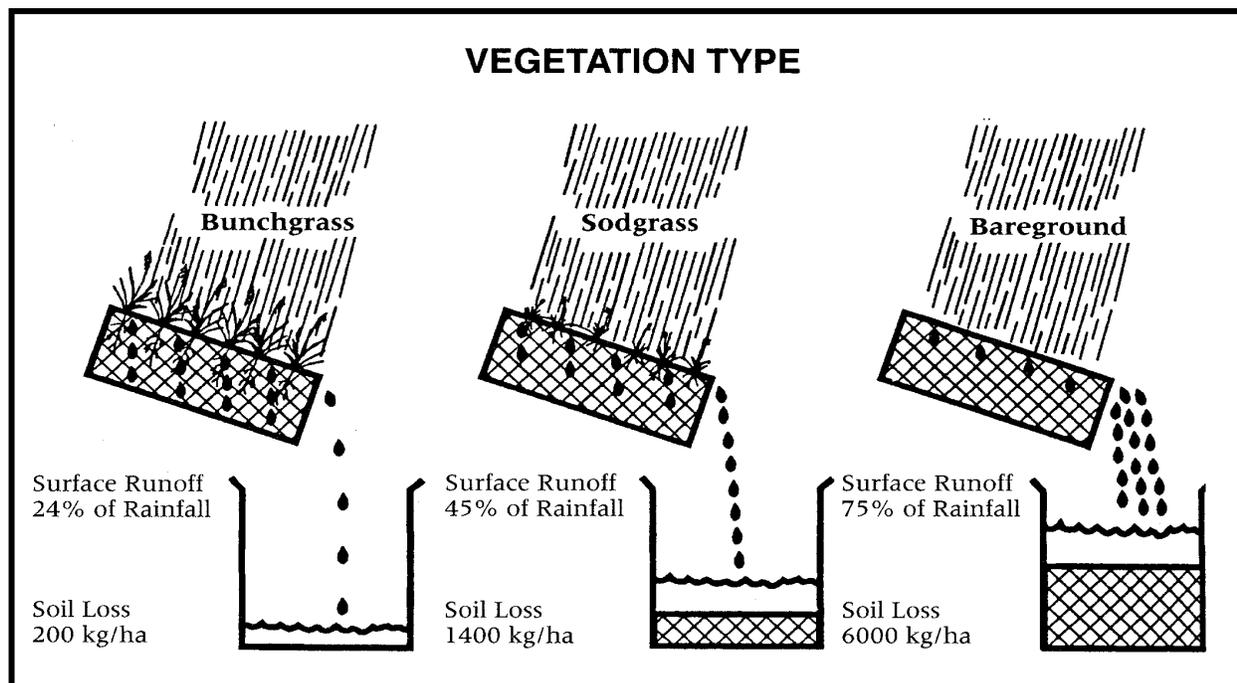


Figure 4. Influence of vegetation type on sediment loss, surface runoff, and rainfall infiltration from 10 cm of rain in 30 minutes. (Adapted from Blackburn et al. 1986, by Knight 1993 as used by Holechek et al. 1998)

depending on site and forage species, general guidelines can be obtained from Standard Soil Surveys produced by the Natural Resources Conservation Service (formerly Soil Conservation Service) in the United States. Other sources of information regarding appropriate stocking rates can be found in local extension offices or by interviewing successful producers who have a long history of production in the area.

Many pastures are overstocked but producers are not aware of the fact. Reasons for the overstocked condition include the use of larger cows than were used by previous generations. Forage intake is related to body size and cows today are 50% larger or more than cows used two generations ago. Another reason many pastures are overstocked today relates to woody species encroachment. Woody (brush) species are continually invading and dominating what were once productive pastures, thus reducing the carrying capacity of those pastures. If this situation is not recognized and either a) the brush removed, or b) livestock numbers reduced, an overstocked

condition occurs. Some properties may also be overstocked due to a lack of appropriate fertilizer and/or weed management inputs that reduce the amount of forage that is produced on the site.

Additionally properties are overstocked because the stocking rate has been based on the total acres of the property instead of being based on the number of *grazeable* acres. Aspects such as brush density, rock cover, distance to water, and slope reduces the amount of property grazing animals are able to utilize and stocking rates should be adjusted accordingly. For all of the reasons cited above, in many instances, stocking rates exceed the carrying capacity of the land thus reducing the amount of ground cover and placing the property, production system, and environment at risk.

In order to discuss stocking rate and its effect on animal performance, it is necessary to establish some definitions. **Stocking rate** is defined as the number of animals on a given amount of land over a certain period of time. Stocking rate is generally expressed as animal units per unit of land area. **Carrying capacity** is the stocking rate that is sustainable over time per unit of land area. A critical factor to evaluate is how well the stocking rate agrees with the carrying capacity of the land. A term that is used to help understand and estimate forage requirements is the **animal unit (AU)** concept (Table 1).

Table 1. Carry capacity in terms of the animal unit (AU) concept.		
Concept	Abbreviation	Definition
Animal Unit	AU	1,000 lb. cow with calf
Animal Unit Day	AUD	26 lbs. of dry forage
Animal Unit Month	AUM	780 lbs. of dry forage
Animal Unit Year	AUY	9,360 lbs. of dry forage

A simple example may serve to better illustrate the concept. Let us assume a livestock producer has 50 head of 1,000-lb cows on 200 acres for 12 months. The stocking rate of this operation would be calculated as follows:

Example 1: Calculation of stocking rate:

$$\text{Total Land Area} \div [(\#\text{AUs}) \times (\text{Grazing Season})]$$

$$200 \text{ acres} \div [(50\text{AUs}) \times (12 \text{ months})] =$$

0.33 acres per AU month (AUM) or
 4 acres per AU year (AUY)

Because cattle and other grazing animals are not the same size, however, it is often necessary to convert to animal unit equivalents. The term **animal unit equivalent** (AUE) is useful for estimating the potential forage demand for different kinds of animals or for cattle that weigh more or less than 1,000 lbs. Animal unit equivalent is based upon a percentage (plus or minus) of the standard AU. Again, assuming a daily forage dry matter intake of 26 lbs. per day, the 1,000-lb. cow is used as the base animal unit to which other livestock are compared. The AUE for cattle that do not weigh 1,000 lbs. is calculated as:

$$\text{AUE} = (\text{BODY WEIGHT}) \div 1,000$$

Table 2 below illustrates different kinds and classes of animals, their various AUEs, and estimated daily forage demand. With this information it is easy to convert different sized animals to AUEs to determine how many different sized animals could be grazed compared with the typical AU.

Table 2. Animal unit equivalent (AUE) and estimated daily forage dry matter (DM) demand for various kinds and classes of grazing animals.		
Animal Type	AUE	DM Demand (lbs per day)
Cattle		
Calves		
300 lbs.	0.30	8
400 lbs.	0.40	10
500 lbs.	0.50	13
600 lbs.	0.60	16
Cows	1.00	26
Bulls	1.25	32
Horses	1.25	32
Sheep	0.20	5
Goats	0.17	4
White-tailed deer	0.17	4

Use of the appropriate stocking rate ensures an adequate amount of ground cover remains in the pasture. As noted previously, ground cover protects the soil resource, maximizes water

capture on the site by improving infiltration rates, and promotes plant persistence and vigor. Beyond these important attributes associated with the adequate ground cover that is directly related to stocking rate, the right stocking rate ensures an adequate forage supply for the animal. Ground cover that does not provide forage to meet animal daily intake requirements has a profound negative effect on animal performance, while at the same time exposing the soil to extreme risk for erosion (Fig. 5).



Figure 5. Effect of adequate versus inadequate forage resources on animal performance.

Grazing Management: Grazing management involves controlling *where*, *when*, and *how much* livestock graze. Close attention to grazing management (primarily stocking rate) is critical if the goal is to maximize profit or minimize loss. Many times, livestock production systems are overstocked. Overstocking is characterized by low quantities of desirable forage and increasing levels of undesirable plants. Too many animals for a given forage resource reduces animal performance, encourages weed infestation, and results in more off-farm purchases such as herbicide and supplemental feed. The objective of grazing management is to efficiently use the forage base while maintaining adequate livestock performance. No single grazing system will meet the requirements of all producers. Certain tracts of land lend themselves to one type of grazing system better than others, and management philosophies and experience levels of producers will likewise dictate how livestock will be manipulated. Generalized grazing systems that facilitate livestock movement, however, have been developed that provide improved control over forage use efficiency. An important point to remember is that *grazing systems generally have less impact on animal performance than do stocking rate or soil fertility*. There has not been a grazing system devised that will lessen the negative impacts of an overstocked pasture or a poor soil fertility program. Some form of rotational stocking system would probably benefit

most commercial livestock producers, while producers of registered livestock may wish to use a moderately stocked, continuously stocked system.

Grazing Systems: Grazing systems can impact soil erosion. Moderate-stocked, continuous grazing, moderate-stocked three-herd, four-pasture, and high-intensity, low-frequency grazing systems appear to have the least effect on infiltration rate and sediment production (Table. 3). Rest period appears to be the critical factor regarding compaction, reduced infiltration, and increased runoff. Most research has been consistent in demonstrating that short-duration grazing increases sediment production compared to moderate-stocked continuous grazing on rangelands (McCalla et al., 1984, Thurow et al., 1986, Weltz and Wood, 1986b, Pluhar et al., 1987). Warren et al. (1986 a,b,c) also demonstrated reduced infiltration rates and increased sediment production compared to no grazing under moderate, double moderate, and triple moderate stocking rates. In this study, 30 days was insufficient to allow for hydrologic recovery. The severity of the effect was increased as stocking rate increased.

Treatment	Infiltration Rate (mm hr ⁻¹)		Sediment Production (kg ha ⁻¹)	
	Midgrass	Shortgrass	Midgrass	Shortgrass
Short-duration (14 pastures)				
Before grazing	95	75	37	63
After grazing	64	55	105	105
Short-duration (42 pastures)				
Before grazing	81	86	41	61
After grazing	85	79	75	53
Merrill 3-herd/4 pasture				
Before grazing	86	80	28	45
After grazing	81	68	71	54
Moderate continuous	89	85	35	30
Exclosure	88		23	

¹ Stocking rate was the same for all treatments.

Special attention should be paid to riparian areas. Inappropriate use of riparian areas by livestock can result in deterioration of the stream bank herbaceous community and increase the risk of stream bank erosion. Riparian areas also serve an important role as buffer strips filtering

sediment from upland runoff. Once stream bank plant communities are disturbed, they are difficult, if not impossible, to re-establish through natural processes. Concrete or gravel limited-access water points have become increasingly popular as a means to minimize damage to riparian areas. Likewise, freeze-proof tanks and stock ponds are alternative methods of providing water to livestock away from riparian areas.

ENVIRONMENTAL CONCERNS

Bacteria: As stated previously, there are currently 386 waterbodies on the 303(d) list in Texas and close to one-half are impaired due to bacteria. Bacteria in a waterbody, as indicated by the presence of *E. coli*, can cause illness in humans and there are many potential sources for bacteria in waterbodies. These sources include waste water treatment plant discharge, ineffective septic systems, wildlife, feral animals (including hogs, dogs, and cats), and grazing livestock. There are several potential BMPs producers can use to reduce the bacteria levels in waterbodies associated with grazing livestock. These BMPs include:

- 1) The use of alternative water sources to reduce the amount of time livestock spend obtaining water from streams
- 2) The use of shade facilities to encourage livestock to spend time loafing in areas away from the riparian area
- 3) The use of salt and mineral locations that encourage livestock to move away from riparian areas
- 4) Rotational stocking grazing systems that reduce the time livestock spend in pastures with riparian areas
- 5) The use of appropriate stocking rates. This ensures an adequate amount of ground cover remains in pastures; thus, pastures act as large filter strips (see below) to minimize the amount of bacteria and/or nutrients that leave the field and enter the waterbody.
- 6) The use of single-animal, hardened water points in streams that do not facilitate loafing in the riparian area.
- 7) Special consideration should be given to riparian area pastures with utilization only during times of the year when impact to the riparian area could be minimized.

The use of one or more of the above suggested BMPs can measurably reduce the amount of bacteria in waterbodies associated with grazing livestock. Producers should realize that bacteria

in waterbodies is a serious issue and brings with it the potential for regulation in the form of TMDLs. Therefore, any proactive measures that can be taken should be carefully considered.

Fertilizer Use: Many forage species used in livestock production systems are introduced from other parts of the world and have been selected for improvements in dry matter production (generally responses to fertilizer inputs), tolerance to grazing, cold tolerance, drought tolerance, insect and/or disease tolerance, etc. Generally, these introduced forage species offer these improved characteristics only when fertilized appropriately. Fertilizers are expensive production system inputs and can prove to be water pollutants if not applied appropriately. Therefore, best management practices for forage and forage-based livestock production includes the use of soil testing to determine the level of nutrients required for the optimum production of the target forage species. Best management practices dictate that fertilizer materials be applied based *only* on soil test recommendations. The use of soil testing to determine fertilizer requirements reduces the potential for both soil and surface water contamination due to over-application of fertilizer nutrients.

Pesticides: An integrated pest management approach seeks to use routine management practices to minimize the use of pesticides on a regular basis. These routine strategies include

- 1) The use of the appropriate stocking rate for the grazing management unit. This minimizes the number of unwanted weed species in the pasture environment, and thus the routine application of herbicides.
- 2) The use of relevant grazing systems that allow for biological control of unwanted, but palatable and nutritious weed species. This again minimizes the routine application of herbicides.
- 3) The use of appropriate fertility programs on introduced-forage pastures. This encourages the growth and vigor of desirable forage species that can out-compete less desirable weed species.
- 4) The use of prescribed burning programs. Prescribed fire can safely and efficiently reduce competition from many weed species, especially those that are woody in nature.
- 5) Close adherence to label directions. When pesticides are required, best management practices include following label directions carefully to optimize target species control and eliminate negative effects to the environment. *To use pesticides in a manner not consistent with label directions is a violation of state and federal laws*

Use of Filter Strips: Filter strips remove sediment and other pollutants from runoff before they are carried into streams. Filter strips also aid in reducing the flow rate of runoff and allowing runoff to infiltrate into the soil to recharge groundwater aquifers. Filter strips, by definition, are gently sloping, densely vegetated areas used to intercept and slow down storm water runoff, acting as a buffer between upland areas and streams. The filter strip's ability to enhance water quality depends on the varieties and mix of vegetation (grass, shrubs or trees) in the filter strip. It is important to note that filter strips are only effective when runoff flows in sheets; concentrated flow leads to erosion that will result in failure of the filter strip. As runoff flows across the filter strip, the top layer of vegetation filters sediment and pollutants, such as bacteria, pesticides, and other nutrients from runoff. By virtue of the vegetation reducing the rate of runoff, infiltration rates are significantly increased, which provides additional filtering for the soil and the groundwater supply. NOTE: Well-managed pastures with appropriate levels of ground cover act as large vegetative filter strips. For additional information on filter strip characteristics, see Table 4 (USDA-NRCS, 2004).

Table 4. Minimum width for vegetative filter strips.	
Slope (%)	Minimum width of buffer strip (ft)
1-3	25
4-7	35
8-10	50

SUMMARY

In summary, forage-based livestock production systems *can* be sustainable with regard to maintaining or even enhancing the environment. Careful attention, however, to best management practices regarding the use of appropriate stocking rates, fertilizers, and pesticides is essential to protecting the environment while at the same time increasing the potential for profit from the production enterprise.

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