SCS-2002-22

GRASS GROWTH AND DEVELOPMENT

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Quick Facts . . .

Grass, like all green plants, captures energy from the sun and converts the energy into sugars and carbohydrates.

Photosynthesis is the process by which leaves take in carbon dioxide from the air through tiny openings and chlorophyll in leaf captures the light energy from the sun, splits carbon dioxide and water and recombines the carbon into sugars.

It takes leaves to grow leaves.

When a plant is not permitted to regrow leaves and roots before being defoliated again, it will eventually die.

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Introduction

An understanding of how the grass plant grows and develops is critical to properly manage forage grasses. When someone understands why and how plant processes work and learns "to see what he is looking at" in the field, then wise management decisions based on the conditions of the pasture can be made rather than trying to follow an "average" set of guidelines. Every piece of land and the animals on it are different and should be managed differently - depending on the situation. Basic knowledge of the biology of plant growth and observation skills that develop only with being in the field, constant monitoring, careful record keeping and a diligent desire to learn result in improved soil, water and land stewardship and profitability.

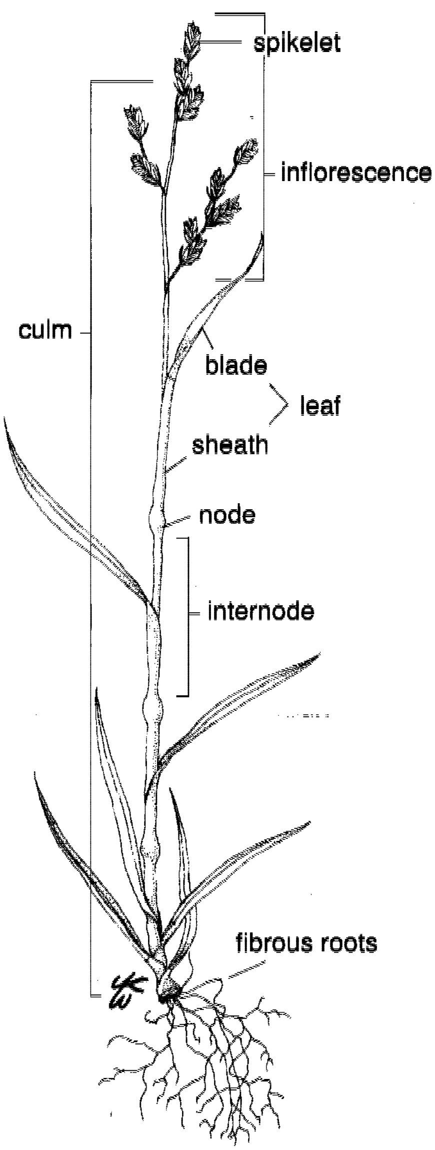
Growth and Development

Leaves

Grass, like all green plants, captures energy from the sun and converts the energy into sugars and carbohydrates, which it eventually uses, along with plant nutrients and minerals for cell division or growth, development and reproduction. In order for that process to occur, photosynthesis must produce the needed energy. Photosynthesis is the process by which leaves take in carbon dioxide from the air through tiny openings and chlorophyll in the leaf (which provides the green color in leaves) captures the light energy from the sun, splits carbon dioxide and water and recombines the carbon into sugars. The sugars then combine with the mineral elements from the soil to make proteins, plant oils, and fats. Unused oxygen and water vapor escape through the leaf pores. Without this remarkable process, all life on the planet would die because only plants create energy in a quantity sufficient to be harvested by other organisms. A grass plant uses sugar, starch, proteins, oils, and fats to grow and produce itself, then other organisms "eat" these foods when they consume the living roots, foliage, seeds or dead plant material which contain energy in the form of organic matter. It takes leaves to grow leaves, hence the importance of grazing or defoliation management.

Warm season grasses produce more leaves than stems in their immature stage early in their life cycle, and more stems than leaves as they mature. Immature leaf tissue is low in fiber and contains high levels of soluble proteins, fats, carbohydrates and oils which meet or exceed the nutrient demands of most grazing animals while stems are high in indigestible fiber and low in digestible nutrients. Grasses can be harvested heavily during the leaf stage, but it is important to reduce harvest or grazing pressure to allow for regrowth of leaves and carbohydrate production to rebuild the plant and root system to maintain healthy grass plants.

It takes leaves to grow leaves. The new growing leaf receives carbohydrates from roots, crowns, stems, or older leaves until the leaf's requirements for growth can be met by the leaf's own energy production. Once formed, an individual leaf is short lived. During its prime middle age it produced more energy than it consumes and exports assimilates to other parts of the plant. At that time, it has the greatest dry weight and is the most nutritious. Leaf senescence (slow death) begins shortly after middle age beginning at the tip and spreading downward. The rate of senescence is influenced by environmental conditions but occurs about the same rate as growth. As the leaf dies, cell contents are mobilized and redistributed to other plant parts - thus reducing the nutritive value of older leaves.



S. L. Hatch, TAMU. 1996.

Research shows that grass production is substantially reduced when more than half of the leaf surface is removed frequently by close grazing or mowing without adequate time to regrow before it is harvested again. When a plant is not permitted to regrow leaves and roots before being defoliated again, it will eventually die. Harvesting foliage does not hurt plants if there is a sufficient recovery period for the plant to grow a new set of leaves and roots.

Roots

Whether growth is from a seed or an established plant, the minimum soil temperature for root growth of cool season grasses is 40-42^0 F., and 60 to 65^0 F for warm season grasses. Three kinds of roots develop in grasses; primary, secondary and hair roots.

Primary roots are the first evidence of growth from germinating seed. Their purpose is to feed the first few leaves and that appear. They stay active for two to three weeks until the secondary roots become functional - then they die. The most critical period in the life of a grass seedling is when the primary roots begin to die and the secondary roots may not have developed enough to properly feed the shoot. This period is particularly critical if soil moisture in the surface few inches of soil is limited and no subsoil moisture is present.

Secondary roots develop at the same time new tillers (branches) and shoots appear. As energy is produced by developing leaves, some carbohydrates are partitioned to secondary roots for growth. These roots must compete with roots from other plants to absorb water and nutrients as they take over the function of the primary root as it dies.

Secondary roots of perennial grasses generally have a life span of about a year, but some can remain active for much longer time. Secondary roots help anchor the plant, absorb water and nutrients, serve as a storehouse for energy and provide a means of transport for water and nutrients from hair roots. The root system of perennials is cyclical, continuously growing new roots, aging, dying and decaying.

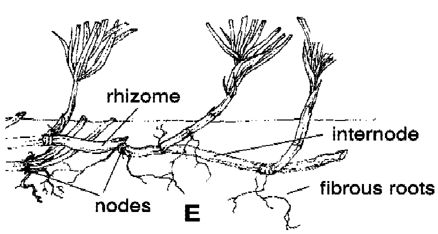
Hair roots are very small, almost microscopic, often only one or two cells long that grow out of the epidermis of larger roots. Hair roots absorb most of the water and nutrients for the plant since they are in intimate contact with soil particles and water.

Root Growth

Root growth and development is affected by many factors, some of which are limited by growth characteristics of the species themselves, whole others are limited by their environment.

For example, roots on perennial grasses are constantly dying as a result of aging, drought, insect and disease and regrowing. Roots cannot make their own energy, so they depend on the leaves to manufacture the energy. Leaves have the first priority for energy, then roots. A plant with few leaves devotes little energy to the root system. When a plant reaches the reproductive stage, the top uses little energy for growth, so energy (carbohydrates) are partitioned away from the leaves and stems to add mass to the root system and reserves to the crown.

When grass plants repeatedly loose their green leaves during the growing season without a chance to recover, a very destructive process results. Top growth that is kept small cannot feed a large root system. Neither can a stunted shallow root system supply enough raw materials to support a large growth of stems and leaves. If the leaf area is too small to carry on sufficient photosynthesis, carbohydrates are not produced and translocated to roots when heavily grazed for extended periods. When a plant is not permitted to regrow, eventually, the supply of energy from leaves and crown becomes exhausted - root growth stops and the root system will begin to shrink as a result of natural mortality. A restricted root system cannot pickup needed nutrients and water for leaves - leaves cannot produce energy - and the downward spiral continues.



S. L. Hatch, TAMU. 1996.

Soil properties that affect plant growth. Root growth and development are affected by many factors, some of which are limited by growth characteristics for the species themselves, while others are limited by their environment. These includethe following:

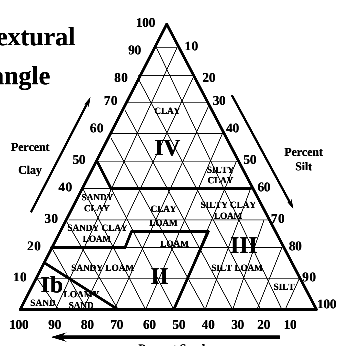
Soil depth will determine root depth as well as species differences that develop shallow or deep root systems. The soil depth at a particular site will eventually determine which species survive. For example, on deep, well drained loamy soils, tall growing species such as big bluestem, B. Dahl bluestem and switchgrass develop root systems five to seven feet deep whereas the root system of blue grama, buffalograss, or common bermudagrass growing on the same soil will be less than two feet deep. Shallow soil will restrict root development. Roots will not penetrate beyond restrictive layers such as bedrock or hardpans that water seldom penetrates. In the case of upland grass species such as buffelgrass or bluestem, a high water table or saturated soils for an extended period will cause roots to drown. For plants to survive on shallow soil sites, they must through necessity, space themselves quite far apart so their roots can develop laterally to get the required water and nutrients instead of growing deep into the soil. Too many plants on shallow soils such as in the Hill Country, will cause rapid loss of available soil moisture , and some will die - generally the smaller, shallow-rooted plants. The effects of drought or even heavy rain on both the soil and plants is minimal in properly managed pastures and rangeland.

Soil texture, (proportion of sand, silt and clay) not only affects the amount of water that can be sorted in a soil (water holding capacity) within the root zone. Typically sandy soils have lower water holding capacity and greater aeration, whereas, clay soils have higher water holding capacity and less aeration. Soil texture also affects fertility of the soil. Sandy soils have a lower capacity to hold cations, (positively charged minerals/ions such as calcium, magnesium, etc.), and have a low CEC, cation exchange capacity. Clay particles have a high CEC and are generally more fertile and hold more water.
Soil texture also affects the amount of oxygen available for root growth (aeration). Roots are made up of living, "breathing" cells that must have oxygen to burn the energy produced by leaves. A lack of oxygen can be caused by too much water or soil compaction in the deeper soil layers.

Plant nutrients are minerals necessary for growth are sometimes mistakenly called plant food. Plant food is manufactured by chlorophyll in green leaves and is not drawn from the soil by roots.

Minerals or plant nutrients such as nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur are used in large

Soil Textural Triangle



quantities. Small amounts of iron, manganese, molybdenum, copper, boron, zinc and other nutrients are also used.   These raw materials come from the soil but only make up about 5% of the total dry weight of plant parts.   Carbon, hydrogen, and oxygen from the air and water in the form of carbohydrates make up most of the remaining 95 percent.   If a plant lacks any nutrient, the growth of the plant will not be more than what is allowed by the most limiting nutrient.

Nitrogen Of all the nutrients, nitrogen is the most dynamic because of the amount needed by the plant and the one most often deficient. It is highly mobile and cannot be stored in soils. It is the nutrient most important in cell division and growth, because nitrogen is the building block of proteins. It is critical for the formation of chlorophyll. The more nitrogen and water available, the more growth potential. Nitrogen is absorbed by plant roots generally in the nitrate (NO_3) form and to a lesser amount as ammonium (NH_4) molecules. Most warm season grasses use nutrients more or less in a 4-1-3 ratio, roughly 50-15-40 pounds of N-P-K to produce a ton of forage, as in the case of bermudagrass.

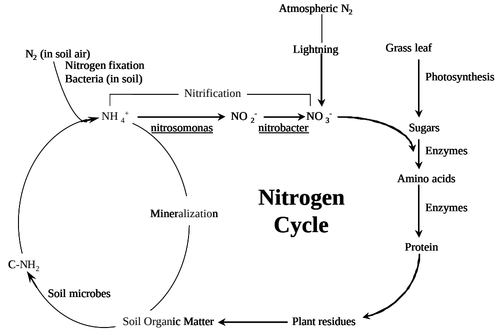
Nitrogen comes from three main sources, rainfall, organic matter and commercial fertilizer.   Sources of nitrogen include: 1) rain (although relatively small), 2) organic matter from dead plant material, insects, microbes, etc., 3) commercial fertilizer, 4) manure, sludge or other waste products, 5) legumes and 6) blue-green algae.

A) Rain drops collect the nitrogen released into the atmosphere by lightning and carry it into the soil.   However the amount is small and may add only 5-10 pounds of usable nitrogen from a single thunder storm.

B) Organic matter is decomposed by microbes that are similar to cattle in a feedlot, in that they “eat” the organic material extracting energy and nutrients from it for their own growth and reproduction.

C) Commercial fertilizer is also an important source of nitrogen as well as other plant nutrients. Because of the cost commercial fertilizer is seldom used on native grass species. If nitrogen in fertilizer or the soil is not in a usable form , such as urea or ammonia, it is converted in the soil to either nitrate or ammonium that can be absorbed by the plant.

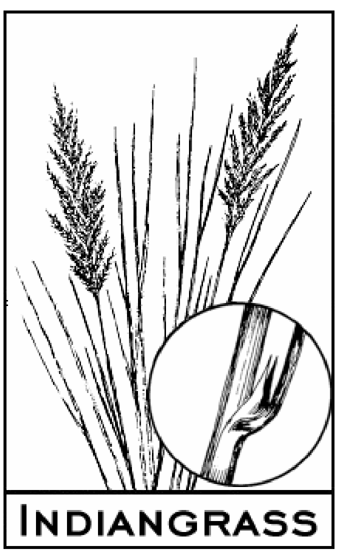
D) Nitrogen and nutrients from manure or sludge is also an excellent and often inexpensive source of plant nutrients. However, manure is often high in phosphorous so there are limitations to the amount that can be applied to prevent runoff contamination to streams and rivers.



E) Rhizobium bacteria in the roots of forage legumes such as clover, medic or vetch will fix and use nitrogen from the atmosphere and share it with the legumes as a usable nitrogen. Upon death of the legume, the plant and nodules on the roots decompose and release nitrogen into the soil for other plants to use. Animals eating legumes recycle the nitrogen in forge plants through feces and urine. This nitrogen source is not only inexpensive, but legumes provide high quality protein forage for livestock.

High salinity levels will affect root growth and cause drought symptoms to occur. Soil salts affect plants by competing with roots for available water. Under droughty conditions, salts pull water out of roots causing them to dehydrate or dessicate. High concentrations of salts will also burn young tender roots and prevent them from developing normally.

Characteristics of the grass species determines the ability of a plant to grow during short periods or limited moisture is to a large degree proportional to root development, number of root and depth of root penetration. The larger the root system, the greater the capacity of the roots to absorb available moisture and nutrients. The ability of grass to survive long term drought is also dependent upon the amount of leaf area to maintain. Generally, tall grasses such as Indiangrass and big bluestem, are replaced by mid size and short grasses such as little bluestem, KR and Kleberg bluestem, and grama. These shorter grasses require less water for maintenance due to less transpiration.



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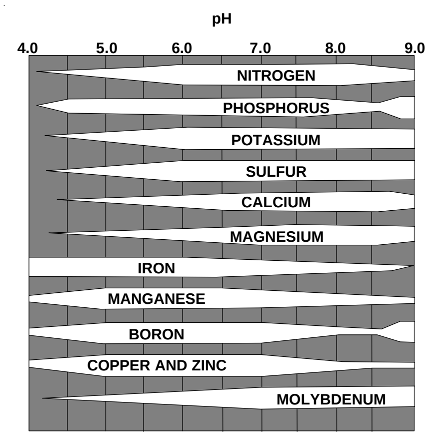
Leaf removal from the intensity of grazing will determine the depth and mass of roots. In cases of severe overuse, root development stops for a period of time and replacement of aging roots is reduced, as previously mentioned.

Soil pH is an important part of plant nutrition. When soil pH is either too high or too low, availability of some nutrients is reduced and root uptake is lessened. Soil minerals and applied fertilizers are not efficiently used and reduced plant growth is the result. Different plant species prefer different soil pH for optimum growth. Soil testing for nutrients and pH is an important part of species selection and forage management.

Water

Water plays a very important role in the processes of plant growth and development. Water supply ranks with temperature as the greatest determining factor as to where certain species of grass will grow. Actively growing grasses are 70 to 95% water, yet grasses use or combine only about 2% of the water that actually passes through the plant. The other 98% is lost through transpiration which also cools the plant. Transpiration is the process by which unused water escapes through the tiny openings in the leaves called stomata. As plants absorb water, nutrients and chemicals that are dissolved in the water are also absorbed. Once they are in the roots, they are transported to all the parts of the plant and used for necessary processes such as photosynthesis, transpiration and cell formation. If a plant has an insufficient amount of leaf surface, water and nutrient absorption is greatly restricted. Limited uptake of water and nutrients results in limited growth.

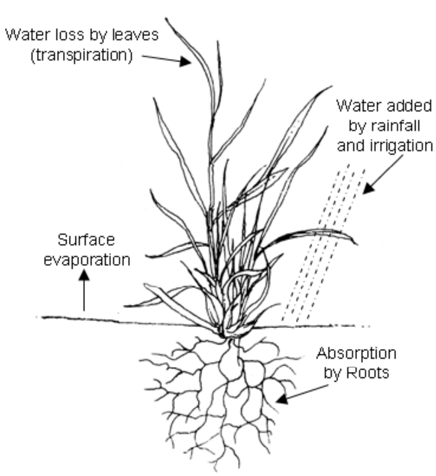
When water is released in the form of transpiration, a water deficiency occurs in the leaf. The plant replaces this water by pulling water from the roots, which absorb water and nutrients from the soil. This process continues until the available water within the root zone is depleted. At that time the grass goes into dormancy or permanent wilt, which is plant death.



Leaf and Stem Growth

Perennial Bunch Grasses

Shoots or tillers (branches from the root crown) of perennial grasses enable the plant to grow, expand in size and produce new leaves and stems. Tillers (growing points) develop new , stems and leaves and stem from a singular growing zone or meristematic tissue, which is located in the enlarged base of the sheath and in the swollen nodes at the root crown. With adequate light and space, these buds produce begin to grow new shoots which become a "mini-plant" with its own set of roots, leaves and eventually seed stems, yet is still attached to the main plant crown. This is what is referred to by wheat growers as "stooling out." Properly grazed grasses will produce more forage than non-grazed grass stands when light causes new leaf growth from the crown. Grasses need to have top growth removed occasionally so plants continue to produce new shoot growth. Short duration high intensity grazing causes grasses to be rejuvenated and develop new shoots when allowed to rest following defoliation.



S. L. Hatch, TAMU. 1996.
M. Vajdak, TAMU. 2002.

Reproductive growth in grass occurs when the stem joints which are crowded together, similar to a telescoping radio antenna expand and raise the seed head. As the stem grows, leaves are pushed up and stem length increased. There are usually three or four expanding leaves between the growing points and the youngest fully expanded leaf. The growing stem actually issues upward from the node as cells reproduce and expand. It rises inside the sheath and eventually breaks through the top out of the "boot" or top part of the enclosed stem. The clasping leaf sheath at the node gives the major strength to tender stems, as it is tightly wrapped around the stem. At exertion of the seed head, stem cells become highly lignified and stiff to support the seed head. This lignification of stems reduces digestibility and increases indigestible fiber in the plant.

Growth habits vary greatly among different species, being influenced by the extent of internode elongation, available water and the direction of growth of the elongated stems. However, one management practice is important for all grasses: ***always maintain a sufficient number of leaves to provide energy for regrowth and recovery of roots and leaves after harvest, to return organic matter back to the soil and cover the soil to prevent rainfall runoff and increase water absorption into the soil.***

Stolon or Sod Producing Grasses (Bermudagrass)

Sod producing grasses have much different growth habits and require management practices different from bunch grasses. Rather than forming individual plants, sod producing grasses produce stolons, (sometimes called runners) and rhizomes (underground stems). Bermudagrass is the most common sod producing grass grown in the southern states. These grasses can be grazed closer to the ground and will take more grazing pressure than perennial bunch grasses since growing points can arise from below the soil. The principles of grass growth and development however remain the same. Failure to follow basic production principles will cause die out and poor production.

Rather than forming tillers as perennial bunch grasses, sod forming grasses produce stolons which are above ground elongated vegetative stems. Species having stolons keep their axillary growth points below the level of normal grazing. Stolons also serve as a means of reproduction when growing points of stems or stolons of sod-forming grasses break through the protective leaf sheath of the basal leaves at nodes and follow the ground surface. New branching plants are formed when roots are produced at nodes in contact with moist soil. Stolons are often planted in place of rhizomes when establishing new stands of bermudagrass.

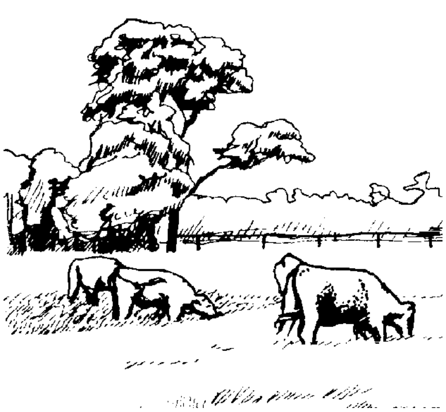
Rhizomes are underground stems that are protected against injury, frost, drought, and burning. The most common example of rhizomes are the large white “roots” found on Johnsongrass. In addition to allowing the plant to reproduce, rhizomes also serve as energy storage structures during winter or periods of drought. In the spring or following a period of drought, limited energy is extracted from rhizomes to initiate new growth from either old crowns, or buds located on the rhizomes. It also allows for planting and spread of the grass.

Grazing Management

The number one cause of poor forage production is improper grazing management. It is critical to maintain sufficient leaves through proper management such as correct stocking rates, rotational grazing, high density short duration grazing, fertilization and weed control or the pasture will begin to deteriorate. Grazing is more than removing herbage from grass plants - it changes everything, such as, root growth, light intensity, plant competition, selection pressure, weed pressure, and physiological changes in all parts of the plant as a result of nutrient and energy deficiencies. For example, a closely grazed plant not only loses its ability to pull moisture from the soil, but its roots also stop growing due to a lack of energy.

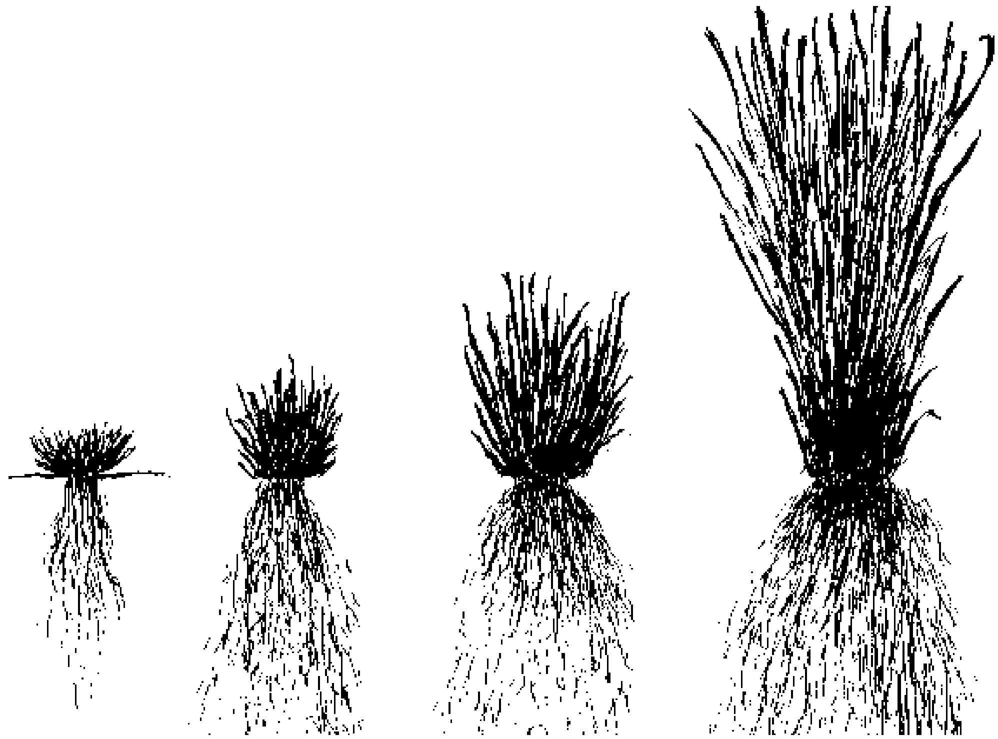
Because the carbohydrates and nitrogen for recovery from defoliation are allocated not from the roots but from remaining shoot tissue, each defoliation event should be regulated to ensure that plants retain sufficient leaf surface to provide adequate assimilates for growth and recovery. Severe defoliation creates severe problems. Heavy continuous grazing exceeds the plant's ability to recover from such abuse and desirable grasses begin to fade away. Grasses subjected to continuous severe defoliation cannot produce at their potential levels.

Forage production is substantially reduced when more than half of the leaf surface is frequently removed and not allowed to regrow, i.e., continuous close grazing. When a plant is not permitted to regrow leaves and roots before being defoliated again it will eventually die. Harvesting the foliage does not hurt plants, if there is a rest/recovery period after severe defoliation. If drought occurs when grass is energy stressed and unable to replenish leaves, it will die faster. During periods of drought, stocking rates must be reduced.



Repeated removal of green foliage causes a corresponding reduction in the plant root system. Top growth that is kept small cannot provide sufficient energy for a large root system, neither can a stunted shallow root system supply enough raw materials to support a large growth of stems and leaves. It is critical to maintain sufficient leaves through proper stocking rates, rotational grazing, high density short duration grazing. Overgrazing (a shift in species composition due to overstocking), will also cause a loss of preferred forage species, and an increase in less desirable grasses and weeds. Animals will preferably graze by choosing the most palatable forages first and leave the less desirable plants. **The number one cause of poor forage production and land deterioration is improper grazing management.** A producer who expects optimum production must manage grass plants to have an adequate "plant food factory."

The following drawing is an approximation of a demonstration by Dr. Wayne Hanselka, of buffelgrass grown in different 55 gallon drums filled with soil. From left to right the drawings of clumps of grass represent the roots and tops of 1) simulated overuse by livestock, 2) rotational grazing, 3) proper use and 4) deferred grazing.



Good pastures and rangeland do not just happen. Understanding what plants need for growth and development and close attention to grazing patterns of livestock and stocking rates will prevent the loss of desirable grasses. Land stewardship to maintain or improve our soils and it's productive capability is every landowner's responsibility.

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Grasses for Texas Rangelands

There is no miracle grass that can be grown everywhere that will do well in every location. As a result, careful consideration of the climate, soil depth, water holding capacity, pH, and use requirements must be taken into account before a grass is selected for planting. Below are a list of grasses and the minimum amount of rainfall needed. Additional information can be found in a publication from Texas Cooperative Extension titled, Seeding Rangeland - B-1379. This is just a partial listing of the more common grasses.

Grass Name	Minimum Rainfall
Bluestem	
Big bluestem	30
Angleton bluestem	10
Gordo bluestem	25
King Ranch bluestem	20
Kleberg bluestem	20
Little bluestem	20
Medio bluestem	25
Old world bluestem (T-587)	20
W.W. B. Dahl	20
Yellow bluestem	18
Black grama	25
Blue grama	10
Blue panicgrass	20
Green panicgrass (south only)	20
Buffelgrass	16
Buffalograss	15
Eastern gamagrass	25
Green sprangletop	10
Indiangrass	16
Kleingrass	20
Lehmann Lovegrass	10
Plains bristlegrass	12
Rhodesgrass (south only)	20
Sand dropseed	10
Sand lovegrass	18
Sideoats grams	14
Switchgrass	20
Wilman lovegrass	10

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