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UNDERSTANDING NATIVE PERENNIAL GRASS GROWTH

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INTRODUCTION

Adapted to grazing and fire, grasses are like no other plant group. Although varying greatly in size, from the giant bamboos of the Asian rain forests and tropics to the tiny hairgrasses of the deserts, all grasses have similar arrangements of leaves, stems (culms), flowers, and roots. No other plant family is more widely useful, and no grass is a parasite on another plant— they all survive and grow on their own with sunlight converted to energy through photosynthesis (Fig. 1). For example: Bamboo shoots are a food item and the hard, woody stems are an important building material. Likewise, straw bundles are used for roofing and in mats, or can be scattered for bedding. Pasture grasses provide forage resources for countless herds of domestic animals and wildlife. Grain crops like rice, wild rice, wheat, corn, barley, oats, grain sorghums, rye, and millet are all grasses. Sugarcane (*Saccharum officinarum*) is a perennial grass that is not only cultivated for sugar but also as a bio-fuel. Giant reed (*Arundo donax*) is used to make reeds for musical instruments. Turf grasses cover playgrounds, home lawns, and athletic fields. Landscaping with grasses has become fashionable. Humans cannot live without them.

Figure 1. Fuzzy, white seedheads and reddish stems of Little Bluestem (*Schizachyrium scoparium*) shining in the fall.
Photo taken in Taylor County, Texas

This manuscript will offer a new approach to understanding how native grasses grow—specifically the reproductive and growth methods of native perennial grasses and how that can help improve management decisions. Although experienced range managers can determine plant composition and forage density by just looking across a pasture, underground plant components are often overlooked. However, these underground plant structures are responsible for what occurs above ground and provides much of the science applied to grassland management.

GRASS MORPHOLOGY

The physical traits of grasses allow them to carry out a variety of biological processes and aid in their ability to survive. Although differences may exist between species in form and function of specific morphological parts, all grasses share the same basic anatomy. Understanding these parts and the roles they serve in plant development can help range managers make key management decisions based on the inventory of perennial grasses present on the land during any growth season.

Starting at the cellular level, all grasses possess columns of cells bundled together that facilitate the movement of water and minerals upward from the roots to stems

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and leaves—including the movement of food downward to the roots of grasses. These columns are known as "vascular bundles," with the cross-section resembling a miniature Halloween mask (Fig. 2). There are two big eyes (vessels) for water movement and multiple opening mouths (sieve tubes) for food. The outer layer of each bundle consists of thick-walled cells (fibers) that strengthen the bundle and make it tough for the grazing animal to consume. Cellulose is a major component of these plant cell walls and cannot be digested equally by all animal species. Monogastrics, or organisms (including humans) that possess only a simple, single stomach, lack the digestive enzymes and gut bacteria to digest cellulose.

However, grazing animals are mostly classified as ruminants. Ruminant mammals have a complex digestive system comprised of multi-chambered stomachs, including a sophisticated rumen compartment containing microbes that can break down cellulose for digestion and absorption by the animal. Examples of ruminants include: cattle, sheep, goats, and deer.

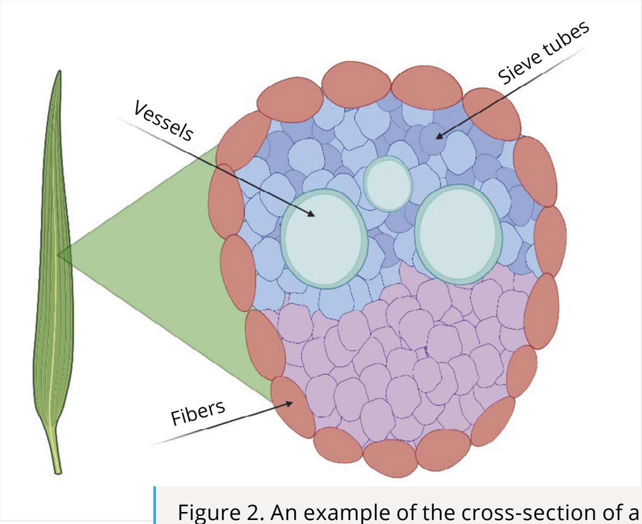

Figure 2. An example of the cross-section of a vascular bundle. *Photo created using BioRender.com*

All grasses also have leaves that consist of a sheath and a blade. The sheath surrounds the stem and protects a bud (i.e., growing point) at its base at a node (joint) where the leaf emerges. Blades lay flat for sun exposure, allowing them to carry out photosynthesis (or incurved/inrolled to reduce the loss of moisture). Grasses can have many variations among the junction (collar) between the sheath and the blade (Fig. 3). These characteristics—such as ear-like extensions of the ligule and hairs—are often helpful in plant identification.

Similarly, grass texture can be used to distinguish different plant species. Like other plants, grasses take up silicon in their roots and deposit it in their tissues as small particles called "phytoliths." Phytoliths are distinctive enough to identify the plants that made them. Silicon is also used in leaf surface spines and gives various grasses a scratchy texture (Fig. 4). Grazing animal's throats have evolved to handle these spines, which prevents them from being a choking hazard when swallowed.

Figure 3. A close-up view of hairs on the collar between the blade and sheath of Tumble windmill grass (*Chloris verticillata*).

Grasses rely on vegetative structures called "buds" and "nodes" for plant growth. Unlike woody plants, grasses cannot initiate secondary growth where actively growing tissue (cambium) increases plant thickness through the addition of cell layers. However, they can utilize a form of growth at the nodes to upright a plant laid over by wind or water. Leaves have some ability for slight extension when clipped off by grazing or by fire, but the most effective recovery mechanism a grass species has is the emergence of a bud at the highest node—which expands into a new stem. Dormant buds, usually present at the base of each stem, can be initiated to replenish active bud sources.

Figure 4. Silicon deposits create fine hairs (or surface spines), which contributes to grass texture.

POLLINATION

The most obvious morphological plant structure used for identification is the seedhead (or "inflorescence"). The inflorescence directly influences pollen transfer and seed development in the grass plant.

All grasses are designed for wind pollination by producing an abundance of pollen in exposed dangling anthers (male) and a feathery stigmatic surface (female) to catch it (Fig. 5). Each silk, or the feathery stigmatic surface, is attached to a developing kernel (i.e., ovary containing ovule), where an egg awaits the arrival of sperm cells produced by the pollen. Grasses can be monoecious or diecious. Monoecious plants contain male and female parts on the same plant, while diecious plants have male and female structures located on separate plants. Both monoecious and diecious grasses can cross-pollinate with each other to enhance the reproductive efficiency. The transport of pollen to neighboring plants is facilitated by modes of action, such as wind or bees. Corn is an exaggerated example of this process. The tassels (i.e., male anthers) produce pollen up high and at a different time on the plant. When silks (i.e., female feathery, stigmatic surfaces) below on the same plant are not receptive, it encourages cross-pollination between neighbors (Figs. 6 and 7).

SEEDS

Grass seeds are botanically designated as a fruit because the grain (caryopsis) consists of tissue layers equivalent to the peel of a banana. The seed develops in a structure called a "spikelet," which varies between plants in the length, width, thickness, and hairiness of their scale-like coverings and decorations. These differences are depended upon for identification of individual grass species.

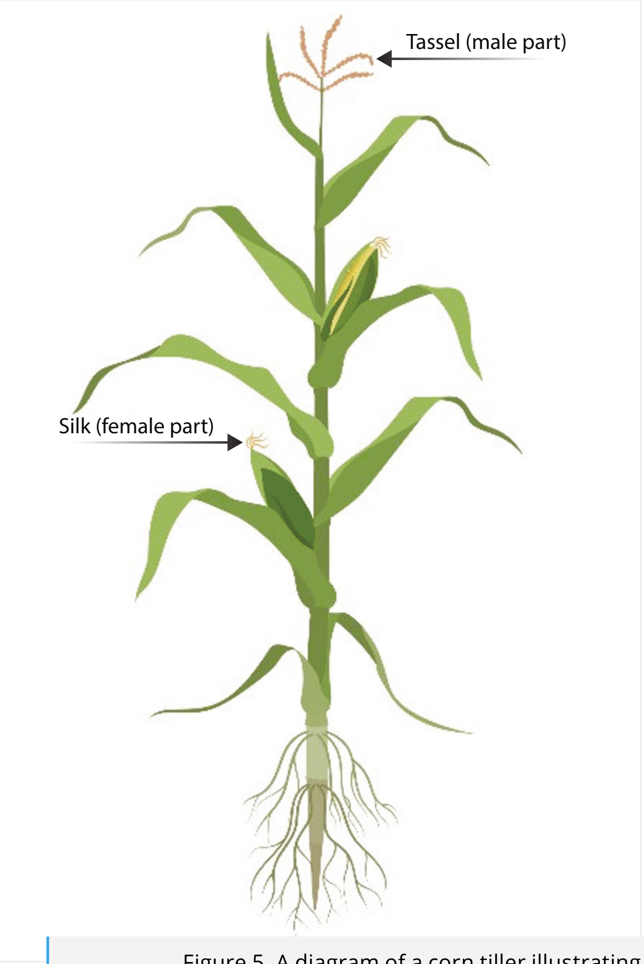

Figure 5. A diagram of a corn tiller illustrating monoecious male and female reproductive parts, which is designed for wind pollination on the grass plant.
Photo created using BioRender.com

Likewise, the inflorescence in which the spikelets are arranged is also critical for identification (Fig. 8). Flower parts, which are so prominent and recognizable in many other plant families, appear in grasses as minute bumps or flaps at the base of the ovule and may serve only to expand and open the spikelet for pollination.

An advantage of grass seeds include their genetic variability and ability to travel long distances. However, their disadvantage is that it has an increased mortality in relation to vegetative buds, making perennial grasses more difficult to establish by seeding. Consequently, establishment of perennial grass from seed has been more heavily researched than establishment by vegetative buds.

NEW GRASS GROWTH

A functional understanding of the plant underground processes and components has not progressed as rapidly as knowledge of above ground plant structure

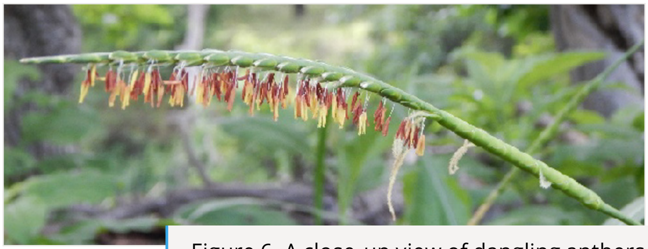

Figure 6. A close-up view of dangling anthers of Eastern gamagrass (*Tripsacum dactyloides*), which is a distant relative of corn.

Figure 7. A close-up view of silks of Eastern gamagrass (*Tripsacum dactyloides*), which is a distant relative of corn.

Figure 8. Inflorescence of vine mesquite (*Panicum obtusum*) with purple stigmas peeking out before its seeds ripen.

dynamics. In fact, internet search logs for scientific research revealed 21,000 hits on establishment by seed, compared to 13,000 on establishment from buds. Current research has shown that perennial grasses reproduce by vegetative processes through asexual reproduction. Seed contribution to maintain an established grassland is less than 1 percent of the total reproductive effort—contradicting earlier range science research, which suggested that seed head formation was necessary for perennial grass reproduction. Consequently, many range grazing and burning management plans, especially within federal agencies, were established based upon former ideologies in the field of range science. The development of new strategies based upon vegetative properties of perennial grasses is crucial to the ability of landowners to optimize forage quality and quantity.

THE BUD BANK

Plant components within a few inches below the soil surface play a major role in maintaining reproduction and density of every native grass species because vegetative buds at or beneath the soil surface are responsible for most perennial grass reproduction. Collectively, buds that exist on a single grass plant are called the bud bank. Research findings from Benson et al. (2004) shows that more than 99 percent of new tillers are produced from this bud bank. Through evolution, bud banks developed in the soil to facilitate regrowth after top growth is destroyed by fire, grazing, or drought (Fig. 9). Ott and Harnett (2012 and 2015) showed how variability between bud banks relates to differences in plant photosynthetic pathways and growth forms, such as bunch grasses versus rhizomatous plants.

Vegetative buds are produced by meristematic tissue existing in each junction of a leaf and a stem (also called tiller). In plants, meristem is the area of tissue from which new growths are formed. Vegetative bud functions are very complex. Research continues to undercover more information on their function in perennial grass growth processes and how these processes differ among perennial grass species. From a practical management standpoint, knowledge of how bud numbers and characteristics differ between grass species can allow managers to apply techniques to facilitate healthy rangelands based upon the grass inventory at hand.

Bud banks contain three different types of vegetative buds: active, dormant, and dead. Active buds are resources for reproduction, but require an environmental event such as rain, fire, or grazing to initiate tiller growth. These buds will begin tiller growth within a period as short as 24 hours after receiving an

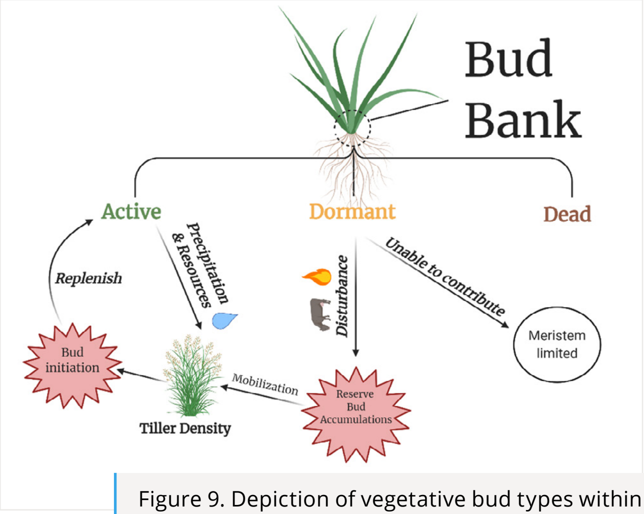

Figure 9. Depiction of vegetative bud types within the bud bank and their subsequent contribution to tiller density. *Created using: BioRender.com*

environmental stimulation. The new tillers grow new buds to replenish the bud bank.

Dormant buds perform like a savings account by becoming an active bud depository when initiated by a disturbance such as fire or grazing. A second impulse mobilizes them to produce tillers and enter the bud replenishment cycle. Dormant buds can live 6 to 10 years or even longer.

Dead buds do not contain meristem—and as a result, can never be activated. If a plant has too many dead buds it becomes meristem limited. When too many plants are meristem limited, the particular species disappears from the plant community. Disappearance may be temporary or permanent depending upon management decisions.

Perennial grasses can be produce by both buds and seed, although more than 99 percent of new tiller growth comes from the bud bank. Seed life spans are short-lived and do not extend beyond 1 year. However, buds are long-lived and have a potential life that may exceed 5 years. Since bud life varies among grass species, current research efforts are focused on determining which species have the longer living buds. Vegetative buds respond quickly to environmental changes like rain, fire, and grazing.

Examination of the bud bank provides an indication of future plant community composition.

Research has revealed differences in bud banks between cool-season and warm-season grasses. Cool season grasses typically have a smaller bud bank with a short-lived bud life of 1 to 2 years. Their bud banks are almost entirely depleted during the growing season and are sensitive to variable environmental conditions. Because of these bud bank characteristics, cool-season grasses are prone to disappear from the plant community when environmental conditions are unfavorable for plant growth.

Warm-season grasses have an extensive dormant bud bank, making their buds multi-aged, and therefore enabling them to be long-lived. These capabilities allow warm-season grasses to respond quickly and positively to rainfall. In addition, warm-season grasses are more resilient through dry periods than cool-season grass species.

APPLICATION OF BUD BANK KNOWLEDGE TO GRASS MANAGEMENT

Quantifying and describing bud bank densities for dominant grasses will greatly improve the ability of range managers to apply appropriate management strategies. For example: Bud banks of various perennial grasses are affected differently by the season in which natural or prescribed burns occur, fire intervals and grazing timing, duration, and intensity. Employing techniques that maximize bud bank densities is paramount for maintaining healthy native grass populations, plant diversity, and plant community resiliency.

Table 1 shows data that is currently available on bud characteristics and densities of some dominant grasses. This information illustrates how bud banks influence the above ground growth habits of the listed grasses. For instance, King Ranch bluestem (KR bluestem) is a prolific invader, easily forms monocultures, and is often found in areas where it is not wanted. Examination of its bud bank, which contains a maximum of 22 buds with a minimum of 12, offers a partial explanation for this behavior.

Research shows that any type of disturbance will activate this plentiful bud supply to develop new tillers. The expansive size of KR bluestem's bud bank and its capability to activate buds provides a plausible reason for the plant's aggressive behavior.

Blue grama possesses a smaller, tightly clustered bud zone. With a maximum of six buds and a minimum of four buds on each plant, this grass is not as competitive as KR bluestem. Figures 10 and 11 illustrate blue grama's dense buds, which contain many leaf scars.

Understanding how native grasses grow—specifically the reproductive and growth methods of native perennial grasses—builds upon the landowner's above ground knowledge of native grass production and plant community composition. This foundational information will assist in making the best management decisions, such as prescribed fire, timing of grazing, and the grazing duration to reset nutrient cycles simulating bud growth and development. Making informed management decisions, which incorporates the bud bank and below ground dynamics, is the first step in ensuring enhanced soil health, functioning nutrient cycles, and optimized forage production during variable climate fluctuations.

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Figure 10. An enlarged example of meristematic potential of future growth for blue grama.

Figure 11. A blue grama tiller showing the longevity and number of buds on a single grass tiller.

Table 1. Vegetative bud characteristics of some major grasses*			
Species	**General Notes on Bud Zone Appearance**	**Max. No. of Buds**	**Min. No. of Buds**
Blue grama	Tightly clustered bud zone Large over-wintering bud bank Dense buds Many leaf scars	6	4
Buffalograss	Short Fragile buds	5	2
Hairy grama	Short and clustered rhizomes Lots of budding from rhizomes	3	1
Hall panicum	Very short Hairy rhizomes	4	2
Kleingrass	Lots of above ground auxiliary buds	13	7
KR bluestem	Lots of above ground auxiliary buds	22	12
Little bluestem	Tightly clustered above ground axillary buds Leaf scars	12	6
Purple threeawn	Buds form up to first node	8	3
Sand dropseed	Large Elongated basal buds Minimal reserves	8	2
Sideoats grama	Tightly clustered axillary and basal buds Big reserve pool	16	4
Silver bluestem	Hairy nodes Higher branching due to buds up to 3 or 4 nodes	8	5
Texas wintergrass	Meristem limited Small over-wintering bud bank Small buds Limited dormant buds	4	1
Western wheatgrass	Large buds spaced far apart Large over-wintering bud bank Mimics warm-season grass below ground Rapid activation from bud bank Rapid tillering	12	4

*Adapted from: ***https://agrilife.org/howgrassesgrow.*** This data may also be found at: ***https://agrilife.org/howgrassesgrow/.*** As more data is collected on the listed plants, as well as others, it will become a reliable aid in determining appropriate range management strategies.