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INTRODUCTION

The Poaceae (Gramineae) has approximately 785 genera and 10,000 species (Watson and Dallwitz 1992). Based on genera, this places the grasses as the third-largest family of flowering plants after the Asteraceae (sunflowers) and Orchidaceae (orchids). Grasses are fifth in the number of species behind the Asteraceae, Fabaceae (legumes), Orchidaceae, and Rubiaceae (madders) (Good 1953). Grasslands occupy a third of the earth's land surface (Schantz 1954), and almost two-thirds is used for grazing. Grasses occur on every continent and within nearly every terrestrial ecosystem. Hartley (1954) estimates that there are more individual grass plants than all other flowering plants combined. Based on completeness of representation in all regions of the world and on their percentage of the world's vegetation, grasses far surpass all others (Gould and Shaw 1983). The major uses of grasses described next support the assumption that they are by far the most important agricultural and ecological members of the flowering plants (Figure 1).

FOOD FOR HUMAN CONSUMPTION

The cereal grains (barley, corn, millet, oats, rice, rye, sorghum, wheat) supply the bulk of food consumed by humans (Figure 1). Rice feeds more people than any other food product. Wheat cultivation covers more area than any other crop. No crop covers a wider geographic range than corn. The world's main source of sugar is sugarcane. Even the "woody" grasses are a source of nutrition (e.g., bamboo shoots).

Figure 1. Grasses are most important as a source of food for humans (a. wheat field, b. harvesting corn, c. most barley production in the United States is used in the manufacturing of beer), as forage for wild and domestic animals (d. native pasture, e. hay cut from improved grass pastures), and in soil conservation (f. native range improvement practice).

The major dietary substance found in grass caryopses is carbohydrates. These carbohydrates are stored in the endosperm, nutritive tissue used during seed germination and seedling establishment, which, along with the embryo, is the major part of the grass caryopsis. The seed containing the endosperm is what the human race desires. It is what makes flour, cornmeal, rice, oats, beer, sake, and some whiskeys (Figure 1). This is why all cereal species are annual plants. Annuals put most of their energy into reproduction (creating more seeds) rather than roots and vegetative structures, which will die at the end of the growing season. The seeds used to ensure propagation of the annual species are harvested and put to multiple uses by humans. Carbohydrates in the endosperm are the substance upon which most civilizations have developed and been maintained. It is a farmer's ability to feed many individuals, not just himself and his family, that allows others to pursue such activities as the arts, manufacturing, trade, education, bureaucracies, and, alas, war—all part of the fabric of human civilizations. The classic example of endosperm is the large, white "exploded" portion of a piece of popcorn. The soft, sweet portion of a partially

Table 1. Area Planted (in the case of hay, area harvested), Production, and Value of Major Grass Crops in Colorado.[1] Data are from Colorado Agricultural Statistics 2005 (on-line).

Crop	*Area (× 1,000)*		*Production (× 1,000)*	*Total Value (× 1,000)*
Barley	80 a	32 h	9,086 b	$25,895
Corn				
Grain	1,200 a	486 h	140400 b	$301,860
Silage	100 a	40 h	5,400 t	$54,450
Oats	75 a	30 h	1,100 b	$1,980
Proso millet	370 a	150 h	7,920 c	$21,384
Grass hay	750 a	304 h	1,125 t	$76,500
Sorghum				
Grain	280 a	113 h	5,400 b	$9,223
Silage	19 a	8 h	266 t	$5,187
Wheat				
Winter	2,300 a	931 h	45,900 b	$146,880
Summer	15 a	6 h	980 b	$3,087
Grand Total	5,189 a	2,100 h	–	$646,446

1. Area is presented as acres (a) and hectares (h), while production is bushels (b), tonnage (t), or hundredweight (c).

popped kernel, sometimes referred to as "old maids" or "duds," is the embryo. The golden covering of the endosperm and embryo, which more often than not gets stuck between one's teeth, is the seed coat.

Roughly 13 percent of Colorado's land area was planted in cereal crops or harvested for hay in 2004 (Table 1). Corn, wheat, and grass hay were the largest grass products based on dollar value. Wheat had nearly twice as much area planted as corn did, but corn's total dollar value was more than twice that of wheat (Table 1). Corn, in fact, accounted for 55 percent of total grass products in Colorado in 2004 ($356,310,000).

FORAGE FOR WILD AND DOMESTIC ANIMALS

The majority of large herbivores characteristic of the world's grasslands are dependent on grasses as a major portion of their diet. Man, in turn, depends upon wild and domestic herbivores as a major source of protein and other nutrients (meat, blood, milk). These animals are also significant as the source of leather (hides) and animal fiber (wool, mohair, and the like). Livestock and livestock products were valued at over $3.5 billion in Colorado in 2004 (Colorado Agricultural Statistics 2005, on-line).

In Western societies, large infrastructures have been developed to supply these animal products to an ever enlarging and demanding population. Corn and sorghum silage is harvested for livestock in feedlots (Figure 1). Also, much of the corn, millet, and sorghum grain is used as feed for cattle, swine, and poultry (Table 1). Table 2 shows the estimated number of domestic livestock in Colorado. Colorado's highest rankings among the fifty states in terms of livestock are for the number of sheep and lambs (5th), wool production (5th), lamb crop (9th), and total number of cattle (10th).

While it is easy to envision the role and importance of grasses to the large herds of herbivores that once occupied the grasslands of Africa, Eurasia, and North America, one often forgets about the importance of grasses to other wildlife. There are many graminivorous

Table 2. Colorado Livestock Numbers and Rankings among All States. Data are from Colorado Agricultural Statistics 2005 (on-line).

Commodity	*Unit*	*Number (× 1,000)*	*Categories*[1]	*Rank*
Cattle and calves	head	2,500	—	10
All cows	head	—	740	22
Beef cattle	head	—	639	18
Calf crop	head	—	740	19
Milk cows	head	—	102	23
Chickens	head	4,991	—	23
Layers	head	—	3,960	24
All hogs and pigs	head	800	—	15
Pig crop	head	—	2,385	—
All sheep and lambs	head	365	—	5
Lamb crop	head	—	165	9
Wool production	pounds	2,570	—	5

1. Categories do not sum to total number by commodity.

upland birds and small mammals. Also, grasses compose a significant portion of waterfowl diets. Mannagrasses (*Glyceria*), cutgrasses (*Leersia*), and wildrices (*Zizania, Zizaniopsis*) are of special importance to birds that utilize swamps, lakes, and marshes. Some migratory birds not only use wetlands dominated by grasses but also overwinter on grain fields and improved pastures (Gould and Shaw 1983).

SOIL CONSERVATION AND LAND IMPROVEMENTS

A majority of the world's most productive soils now used for grain production were developed under perennial grassland cover (Gould and Shaw 1983). Removal of this native, perennial grass cover by plowing or poor grazing management has led to both wind and water erosion, and a large amount of topsoil has been lost over the centuries (Figure 1). Reestablishment of a perennial grass cover is a common practice in soil conservation and range improvements. A "good" cover of grasses not only stabilizes the site, reducing erosion, but helps in rebuilding depleted soils. Numerous state and federal agencies have developed over the past century to assist landowners in reducing erosion and returning lands to a more productive and economically viable state. Specific industries have developed, focusing on improving the condition of rangelands and restoring other disturbed sites (e.g., land rehabilitation, mine reclamation).

Some grasses adapted to restricted ecological niches have been used for specific erosion control purposes. For example, vetiver grass (*Vetiveria*) is used extensively in southern Asia and Oceania for erosion control and terrace production (National Research Council 1993). Beachgrass (*Ammophila*), with its extensive rhizomes, has been used to stabilize sand dunes. The same is true for the native grass *Redfieldia,* used to stabilize "blowouts" in southeastern Colorado.

TURF AND ORNAMENTALS

Often overlooked but not insignificant is the use of grasses for turf and ornamentals (Figure 2). Grasses with rhizomes, stolons, or both (sod formers) have been used for centuries to

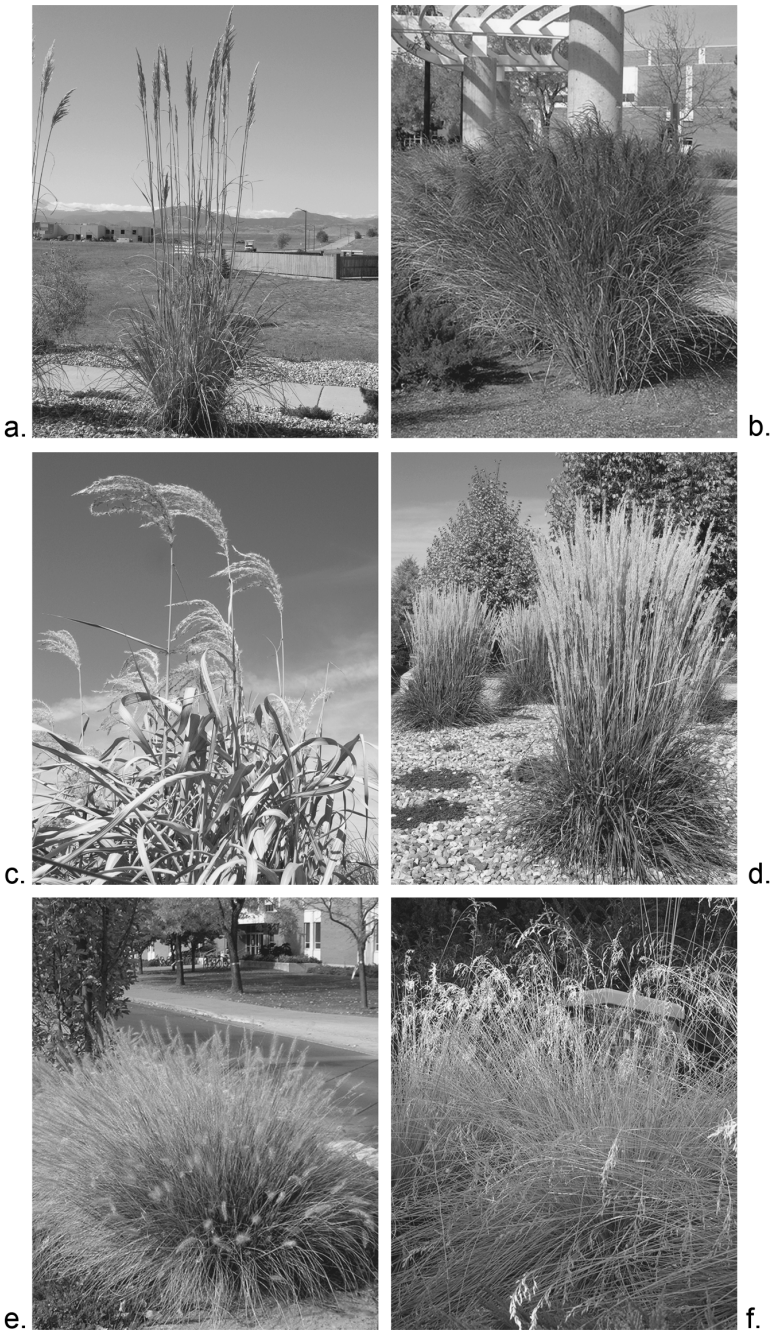

Figure 2. Grasses are also used for turf and ornamentals. Ornamental grasses commonly used in Colorado include (a) *Saccharum ravennae,* (b) *Miscanthus sinensis,* (c) inflorescences of *M. sinensis*, (d) *Calamagrostis* x *acutifolia* "Karl Foerster," (e) *Pennisetum alopecuroides,* and (f) *Helictotrichon sempervirens*.

produce a dense, thick cover that will resist use (primarily foot traffic) and be aesthetically pleasing (generally of uniform color and density). Most common uses of turf grasses are for lawns, parks, highway right-of-ways, golf courses, and athletic fields of all sorts (Gould and Shaw 1983). Maintenance of turf supports a multi-billion-dollar industry, supplying seed, fertilizer, herbicides, insecticides, specialized machinery, sprinklers, hoses, and similar materials, as well as lawn care services. In Colorado the dominant turf grasses are familiar to most: bluegrasses (*Poa*), fescues (*Festuca*), bentgrasses (*Agrostis*), and ryegrasses (*Lolium*). Many of the turf grasses have escaped cultivation and occur as permanent members of our grass flora, and they are found in this book.

Recently, grasses have become much more popular as ornamentals. Bamboos (*Bambusa, Dendrocalamus, Phyllostachys,* and other genera) have traditionally been cultivated, but now many herbaceous grass species are being incorporated into human landscapes (Figure 2). This popularity is based on the relatively cost-effective propagation of herbaceous grasses, their ease of maintenance, adaptability to a wide range of soil textures and nutritive levels, and versatility. Their uses can vary from ground cover to single specimen plants (*Erianthus* [*Saccharum*], *Miscanthus*), mass planting (*Calamagrostis, Festuca, Pennisetum,* and other genera), and erosion control. Both exotic and native species (e.g., *Panicum, Andropogon, Sorghastrum, Chondrosum, Bouteloua*) are used. Colorado native taxa used for ornamentals will be found in this book, but the ornamentals that have not escaped cultivation are not included.

OTHER USES

I have heard that more structures are composed of bamboo than of stone, brick, and wood combined. While this may be an exaggeration, it points out the importance of bamboo to millions of people living in tropical Central and South America, Africa, Asia, and Oceania. Not only is bamboo used in construction, but it can be a source of nutrition (e.g., bamboo shoots) as well as an occasional source of grain in times of famine (Gould and Shaw 1983). The nonfood uses of bamboo are endless, but here are a few: poles and posts for building construction, fence posts, bridges, boat masts, ladders, cages, flooring; shafts, spears, bows and arrows, fishing poles; handles for tools, whips, knives; furniture; window shades; woven articles such as mats, roofs, baskets; rope and cordage; water conduits and drainpipes; musical instruments; toys; cooking utensils; and a number of miscellaneous items such as chopsticks, pipe stems, sieves, writing paper, facial tissue, and cigarette papers (Gould and Shaw 1983; Chapman 1996).

Lemongrass (*Cymbopogon*) is used as a flavoring in cooking and, along with vetiver grass (*Vetiveria*), is harvested for essential oils (National Research Council 1993). Other aromatic grasses (*Hierochloë, Anthoxanthum*) that contain coumarin are used for perfumes, hair tonics, and flavoring vodka.

HARMFUL GRASSES

Grasses are fairly benign, doing little harm to man or beast compared to the benefits they afford. That said, some fungi that use grasses as a host have caused serious problems throughout history, and the alkaloids produced by the fungus *Claviceps purpura* L. have caused many deaths when ingested in significant quantities. "Ergot" is the term most commonly used for these endophytic fungal diseases. Ergot outbreaks caused hundred of thousands of deaths in the Middle Ages after contaminated grain (rye, for the most part) was

ingested (Lorenz 1979). "St. Anthony's fires" is the term often used for spontaneous hysteria caused by ergot poisoning. I recall hearing that the hallucinations and hysteria during the Salem witch episode in 1692 may have been caused by ergot poisoning. Infected kodo millet (*Paspalum scrobiculatum* L.), a staple food of many in northern India, has caused intoxication and poisoning. The fungus *Aspergillus tamaril* Kita, growing on these plants, produces cyclopiazonic acid, which is toxic to man (Krishnamachari and Bhat 1978). Poisoning by ergot is very rare in modern times because of high agricultural grain inspection requirements. Surprisingly, the alkaloids produced by these fungi have shown the potential for medicinal use (Chapman 1996).

Along with ergot infestation causing fungal secondary compound toxicity, Allred (2005) lists these harmful compounds produced by grasses that can cause poisoning: coumarin, cyanide, nitrates, and oxalates. He also lists other harmful effects of grasses, including dermatitis, hay fever, asthma, and photosensitivity. Often forgotten are the harmful impacts caused by mechanical injury. It is generally the awns or stiff bristles that penetrate soft tissues of the eyes, nose, throat, and underbelly that cause the problem (Allred 2005).

Some feel the accumulation of secondary compounds, mutualism with fungi, and mechanical defenses are adaptations to combat herbivory (Chaplick and Clay 1988; Vicari and Bazely 1993).