Grass in the Timeline of Agriculture 1

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"With the proper practices, grasses can be grown efficiently in most parts of the world, but not everywhere. One of the great problems of agricultural science is to learn how to make these practices more efficient and especially how to adapt them more precisely to the individual soil types. Then, too, we need to discover practices for good grass efficiently on those soils for which we have as yet no satisfactory methods."—C.E. Kellogg, in Stefferud, Grass: The 1948 Yearbook of Agriculture, *p. 55*

Overview

The decision to update the notable *Grass: The Yearbook of Agriculture 1948* is consistent with the intent of its original authors. In his preface to the book, editor Alfred Stefferud (1948) hoped the volume "would not be the last word" but rather, the beginning of a process that would continue to highlight the importance of grass in American agriculture. Stefferud indicated that the authors of the 1948 volume, despite their diversity, all agreed on one thing, "that grassland agriculture is the most important single element in American farming today."

The rationale establishing the importance of grass has changed little since 1948. Clinton P. Anderson, U.S. Secretary of Agriculture at the time, articulated that reasoning clearly and succinctly in his foreword to the yearbook. Grass, he said, was "the foundation of security in agriculture." He pointed out that grass "is not just a crop"; it represents conservation, good farming, prosperity and cooperation. "Grassland is a good way to farm and to live, the best way I know of to use and improve soil, the very thing on which our life and civilization rest." Today, we probably would use the word *sustainability* rather than *security* to illustrate this concept, but the potential of grass to create and support a sound agricultural system has not changed. Anderson also argued that "grass can give us better health," that it is "a tool against floods and a guardian of the water supplies," and that "our land resources will be better used when we can turn more to grass and livestock farming" (Anderson, 1948). Those benefits from grass-based agriculture have been further confirmed today.

On 21 June 1940, Henry A. Wallace, the Secretary of Agriculture who preceded Anderson, and who presumably first suggested the yearbook on grass, delivered a lyrical radio broadcast on "The Strength and Quietness of Grass." He stressed the importance of grass-based agriculture in the context of the challenges facing "the future of the United States." He noted, in his speech, that "the strength and quietness of grass should be, must be, permanently a part of our agriculture if it is to have the strength it will need in the future" (Wallace, 1940). Grasslands will be even more important to sustain life in the future based on the challenges we will likely meet in the 21st century.

"Grassland agriculture is the most important single element in American farming today."—Alfred Stefferud (1948)

The challenges we face in the decades ahead are much more extensive than the ones Wallace identified in the 1940s. In addition to meeting the need for increased food production, tomorrow's agriculture also will need to improve the nutritional and health-enhancing aspects of food production. As we reach and exceed the state of peak oil, we will need to transition to an agriculture that weans itself from fossil fuels. Since fossil water resources are being depleted at an unsustainable rate, we will need to devise farming systems that are much less dependent on irrigation. As climate change likely fuels more unstable, severe weather patterns, we shall need an agriculture that can remain productive under less favorable, more unpredictable climate conditions. Agriculture will certainly have to act in concert with strategies to restore the health of ecosystems, including an increase in genetic diversity and biodiversity so essential to resilience and self-renewing, self-regulating systems.

"Grassland is a good way to farm and to live, the best way I know of to use and improve soil, the very thing on which our life and civilization rest."—Clinton P. Anderson (1948)

The end of cheap energy due to peak oil poses the most immediate challenge requiring a paradigm shift in our agriculture and food system. Richard Heinberg (2007), one of the premier scholars addressing our new energy situation, has succinctly described our new situation:

> The world is entering a period of change unlike any in history. This will be an inherently perilous time, because it will involve a forced and rapid transformation in the energy system on which our societies, and our very lives, depend. The transformation will involve the invention of new technologies and the exploitation of new resources—as was the case with earlier great economic watersheds. But this time change will be propelled not merely by new opportunities. Instead, it will be thrust on us as a result of the depletion of the energy resources that enabled the creation of industrial economies throughout the past two centuries: namely coal, oil, and natural gas— though first and foremost, oil.
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> Less than two centuries ago, most of the work done in even the wealthiest nations was accomplished by muscle power (human or animal). But muscles are puny compared to fuel-fed engines. We learned this with engines fed first with wood, then coal. But oil is a fuel superior to either of these. So magical are the benefits of oil that it was inevitable that we would find more and more uses for it. And so we have built an entire way of life around it.
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> The world is not about to *run out* of oil. There are still many hundreds of billions of barrels of petroleum that can be extracted from the Earth's crust. However, the rate at which oil can be extracted is subject to geological limits, and soon those limits will begin to constrain our ability

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—Henry A. Wallace (1940)

Photo by Lynn Betts, USDA, Natural Resources Conservation Service

to produce oil at the ever-expanding rates that growing economies demand. If we are not already doing so, we soon will be entering the transition from a century-and-a-half during which the available supply of oil grew each year, to a future characterized by declining annual supplies. This transition is commonly referred to as *Peak Oil*.

Together, the challenges of peak oil, declining fossil water, and climate fluctuations make it apparent that we shall need a future agriculture that relies more on ecosystems management and less on single-tactic functions. Continuing to rely solely on single-tactic functions (e.g., applying fertilizer to compensate for nutrient depletion, applying pesticides to get rid of pests) grounded in chemical and physical management that require intensive energy inputs will not serve us well in our emerging world.

Clearly, expanding grasslands in American agriculture will not solve all of the problems we will encounter due to these impending changes, nor will they alone transform agriculture. But they can play a significant role in our new future. Consequently, while the fundamental rationale for upholding the importance of grass in American agriculture has not changed, much has changed on our agricultural landscape that may, in fact, make grasslands even more important now, more than a half-century later.

But grass seems to retain another feature today that is similar to 1948, namely, that “grass has been a comparatively neglected matter-of-course” (Stefferud, 1948, p. vii). The importance and potential of grass farming for American agriculture is scarcely more appreciated today than it was in 1948.

The reasons grass continues to be such an undervalued resource in American agriculture are, no doubt, complex. It will be important to begin this volume with some historical and ecological context so that we can better appreciate that complexity and properly evaluate the role grass can play in the future of agriculture.

Anthropologist Ernest Schusky (1989) provided some useful context for understanding the place of modern agriculture in the long sweep of history and therefore for assessing the potential role of grass in American agriculture today. Schusky contends that energy has always played a key role in the acquisition of food by human beings. For most of our tenure on the planet, we have been gatherers. We hunted animals and collected plants for food. From an energy-efficiency perspective, this was a very effective way to feed ourselves. No energy was required for production or domestication. We simply gathered food, prepared it, and ate it.

"Grass is the forgiveness of nature—her constant benediction."—Senator James Ingalls, Kansas, 1872 (Ingalls, 1948)

The invention of agriculture, approximately 10,000 to 12,000 years ago, spawned the Neolithic Revolution. During this era, we domesticated plants and animals and used human and animal energy to produce our food. While such agricultural practices were much less energy efficient than hunting and gathering, they presumably offered other advantages. Eventually, it must have occurred to our ancestors that there was a benefit to domesticating their favorite plants and animals to ensure an adequate supply of their preferred foods.

But a more significant shift in our food system took place much later. Around 1930, we ushered in a new era of agriculture. Schusky calls this new period the *neocaloric era* because it is based almost entirely on "old calories," namely, fossil fuels. The defining characteristic of this modern food system is that it replaces energy produced by human and animal labor with fossil fuel energy. But from an energy-efficiency standpoint, it is the least-effective food system we have ever had. Industrial agriculture, for the first time, *consumed* more energy than it *produced*! Schusky cites one egregious example—he asserts it takes "about 2200 calories of fossil energy to produce a one-calorie can of diet soda," which he suggests is "downright embarrassing to human intelligence."

Nevertheless, our industrial food system offers other benefits that we apparently value more than energy efficiency or sustainability. The qualities we seem to admire most are maximum production and short-term return. That mind-set has led industrialized countries to adopt an agriculture system based on the same principles as any other industrial economy—specialization, simplification, and consolidation. It is those principles that led us, during the last half century, to transform even more of our grasslands to a few monoculture crops grown in extremely simple rotations, such as soybeans [*Glycine max* (L.) Merr.] and corn (*Zea mays* L.) or wheat (*Triticum aestivum* L.) fallow. Similarly, genetically uniform animals began to be raised in strict confinement and nourished with the protein and calories from crop monocultures. Grass increasingly came to be regarded as part of yesterday's agriculture.

As we have entered the 21st century, we see that the virtues of short-term returns and maximizing production to the exclusion of most other goals may no longer serve us well. Furthermore, as Schusky pointed out, the neocaloric era is of necessity a very short epoch because the calories that sustain it are "old" calories. Fossil fuels are stored energy from sunshine. Fossil fuels and radioactive materials have accumulated in the earth over many millennia, and once they are gone, there is no further stored energy, so far as we know, to replace them. At the rate we are extracting this stored energy, we are likely to reach our new energy threshold sooner rather than later. So, the compelling questions we face are, "What will the next era of food production be like?" and "What kind of food culture can we develop to envision and sustain it?"

We are seeing growers taking a fresh look at grass to help them address some of these challenges. Intensive rotational grazing systems have been adopted by a growing number of dairy farmers. New markets are beginning to appear for grass-fed beef, free-range poultry, and other grass-based products, and these outlets have begun to stimulate a revived interest in grass-based production. New research increasingly shows that farmers can generate more net income with perennial crops than they can with annual crops, and that perennial crops can dramatically reduce nitrate leaching and soil erosion (see, e.g., Randall et al., 1997).

Placing grass in the timeline of agriculture offers us a context for reevaluating the importance of grass and determining its appropriate role for the decades ahead. As it turns out, the crop of grass has an illustrious history.

Historical Timeline

Forages in the Nomadic and Gathering Cultures

Before the rise of farming and its related activities and the breeding of domestic animals, humans existed primarily in nomadic and gathering cultures. They lived on the bounty of the natural environment around them. They primarily hunted and gathered food. Hints as to what this time must have been like can be seen by looking at the relatively unchanged nomadic activities that remain in Mongolia, Asia, and Africa.

When humans lived in nomadic and gathering cultures, they must have foraged where their food was most plentiful. They hunted and gathered to sustain themselves. During this time, animals were abundant, feeding and trampling on large areas of grass, and in the course, breaking down the stems and providing mulch for the ground. This well-mulched soil later became a source of tender, regenerated grass and forage, which was valuable during the critical times of animal breeding and nursing of young animals.

Whenever animal populations exceeded the forage supply, there would be lower reproductive rates and higher mortality of both humans and animals.

Across the world, the various hunter–gatherer cultures of the past were too diverse to label any one of them as a "typical" society, but they tended to share common traits of hunting and gathering. The demarcation is not clear cut between hunter–gatherers and other societies that relied more on domestication. Many societies use a combination of these strategies, a change that most likely started 10,000 to 12,000 years ago. Population densities of hunter–gatherer societies tend to be lower than those of agriculturalists since cultivated land can sustain population densities much greater than can uncultivated land.

Grazing Animal Species Domestication

The book of Genesis may be one of the first written records of humans caring for animals: "Abel was a keeper of sheep, but Cain was a tiller of the ground" (Genesis 4:2b).

Ganj Dareh, a small mound in the mountains of present-day western Iran, was the site of an early Neolithic settlement that flourished around 7000 BCE. Hoof prints found there were unquestionably those of domesticated goats and sheep. Archaeologists have suggested that the animals that left the prints in the drying clays roamed the villages, as livestock often do in present-day Iranian villages. This was the first indication of the presence of domesticated animals. It is likely that farmers of the Near East first learned to tend sheep around 8500 BCE (Leonard, 1973). The earliest date that can be given to the tending of reindeer is 1000 BCE. At least 22 species of animals are known to have been domesticated from their untamed world counterparts.

Global Range of First Domesticated Animals

Sheep 8500 BCE, Zawi Chemi Shandidar, Iraq

Goat 8400 BCE, Ganj Dareh, Iran

Cattle 6500 BCE, Thessaly, Greece; Anatolia, Turkey

Ass 3000 BCE, Nile Valley, Egypt

Reindeer 1000 BCE, Pazyryk Valley, Siberia

Beginnings of Cultivation and Management of Forage Species

The transition from hunting–gathering to herding control of animals and harvesting for grain, hay, or silage occurred over time. This may have been the first deviation from natural selection to human's preference.

Below are some highlights from the history of forage species and management systems (Heath et al., 1985):

- The first records of enclosed meadows were those produced by Anglo-Saxons in the Midlands of Britain about 800 CE.
- The monks of Kelso (ca. 1165) noticed the effects of different forages on the health of cattle and sheep.
- Monks of Couper rotated wheat and grass by planting one year of wheat and five years of grass. This system was later called *ley farming*.
- Red clover (*Trifolium pratense* L.) was cultivated in Italy as early as 1550. Red clover not only increased the abundance of animal feed and manure but also added nitrogen to the soil. Red clover remains the most widely grown of all the true clovers, and Norman Taylor of the University of Kentucky says that red clover has had a greater influence than any other forage plant.
- Alfalfa (*Medicago sativa* L.), today's most widely used forage, was described by Roman writers as early as 490 BCE. It was first introduced to the North American colonies in 1736.

Early Grazing Management Practices

Domesticated animals were herded in the early days, using minimal amounts of harvested feeds. Herding still is used effectively in many parts of the world. Families, tribes, and groups often herded on the *commons*, land that was not privately owned but was regarded as property of the community. Animal species may have been grazed together or separated by species and age. Large herds and flocks were accumulated over time by the rich and powerful. Water was, and still is, the primary limiting factor, and overgrazing quickly became the norm for locations near water. Where water was not available, the land was underutilized. This land tended to deteriorate and became bare and eroded. The ecosystem processes (energy flow, mineral cycle, water cycle, and community dynamics) slowed considerably, and the land became less resilient.

In his book *Grass Productivity*, André Voisin (1988) suggested that "Rational grazing has always been known, for shepherds have always possessed the most marvelous of all electric fences, the living fence known as the dog. With the help of their dogs, shepherds have traditionally practiced what, at a later date, we would call strip grazing, or rationed grazing. These methods were not described on parchment but transmitted orally from generation to generation." According to Voisin, "The oldest description of the rotation of pastures known to me is found in an anonymous French dictionary (*The Agronomist, Pocket Dictionary of the Farmer*) dated 1760."

Voisin's "rotational grazing" method maximizes productivity. It takes into account the needs of the animal and plant rather than the animal alone. The term *rotational grazing* can mean two things: the thinking way of grazing management or a system for rationing out the forage. Strip grazing is a grazing management system that involves giving the livestock a fresh allocation of pasture each

SOME TERMS DEFINED

Grass—Botanically, any plant of the family Gramineae. Generally, in grassland agriculture the term does not include cereals when grown for grain but does include forage species of legumes often grown in association with grasses.

Forage—Herbaceous plants or plant parts consumed by animals (generally, the term refers to such material as pasturage, hay, silage and green chop in contrast to less digestible plant material known as "roughage"); to graze.

Grassland—Land on which grasses and/or legumes constitute the dominant vegetation.

Grassland agriculture—Farming system that emphasizes the importance of grasses and legumes in livestock and land management.

day. It is usually organized within a paddock grazing system, and the animals are controlled by the use of an electric fence. Strip grazing systems are often used where there is a significant excess of forage early in the season and where providing the livestock with access to a larger area would result in waste—for example, through trampling or spoiling by dung. Strip grazing systems are widely used in the dairy sector and for beef and sheep where these animals are being provided with root crops as their primary forage.

As people became more settled, the land was stocked more or less on a continuous basis, leading to overgrazing. Increasingly, stored hays and stubble were used for nongrazing periods. This led to demineralization of the soils (exploitation without replenishment of the fertility resources) and reduction in the naturally occurring organic matter.

Evolution of Forage Species and Grazing Management

For several centuries, numerous forage species have been introduced, tested, and selected for additional use, and many cultivars of each species now are available. Some of these cultivars have become invasive. Hybridized, proprietary genetically modified, and unusual breeds of species have become available in recent times. Modern species and cultivars often have higher yields but may require more inputs. These inputs tend to require more fossil fuels and may tend to, but do not have to, favor monoculture plantings over continuous cover.

In the United States, grazing management during the last 20 to 30 years has been primarily exploitative. Free range, continuous grazing, and limited amounts of rotational grazing became standard practice. Most grazing systems are rotation systems that do not take timing into account and therefore end up either understocked or overgrazed.

Timeline for Forage Species and Grazing Management

The United States has adopted industrialized agriculture more readily than any other part of the world. Many high-yielding, introduced species have been planted in the United States, leading to a monoculture type agriculture that depends heavily on high carbon fuels. In our industrialized systems, farmers tend to harvest and haul products to a central point (feedlot, ethanol plant, confinement), resulting in rapid demineralization of the soil. Native, complex diversified swards of range would lower dependence on high carbon fuels.

Free-range grazing was the standard practice during most of the 19th century. Adoption of the barbed-wire fence changed this practice quickly and ended the great cattle drives of U.S. cattle barons. Although fencing gave farmers and ranchers more control, much of the land continued to be overgrazed. In the last century, countries such as New Zealand and Argentina, as well as some areas in United States and Europe, developed various forms of controlled grazing. However, most of the world's grazing areas remains overgrazed with set stock grazing. During the last 50 years,

Photo, National Park Service, U.S. Department of the Interior

most of the university research on grazing has consisted of set rotational grazing programs that tend to understock and have lower animal days per acre. Much of the forage has been removed by haying or silage harvest. This extracts a high mineral and organic matter cost due to depletion of the soil nutrients or the need to add more fertilizer. Modern, high-energy use crops also have contributed to global warming. The pasturelands (for the most part) are still being eroded, more land is bare, soil minerals are being depleted, and there continues to be considerable desertification. Yet, well-managed pastures can make significant contributions to carbon sequestration, soil building, water conservation, and improved water quality.

Modern Grazing Practices in the United States

Much of the U.S. western rangeland that is government controlled and near urban areas is deteriorating for two reasons: (i) undergrazing and lack of disturbance, and (ii) overgrazing. In brittle environments, undergrazing or lack of disturbance leads to dying plants, while in nonbrittle environments these conditions lead to increased shrubs and trees. According to holistic management principles, for forage plants to recover and thrive, they need animal impact (Savory, 1999).

During the past 40 years, several grazing systems have emerged that consider the rest and recovery needed by the plants: intensive grazing management, management intensive grazing, planned grazing, rational grazing, keyline farming, and strip grazing. Forage chains have been developed to use annuals and perennials that extend the grazing season. Some farmers and ranchers are using holistic management, which takes into account the ecosystem processes and considers the time factor in grazing management. A small group of producers is using organic concepts to produce forage and meat. However, many graziers, especially in the United States, are more dependent on the use of pesticides, herbicides, and genetically modified seeds. These systems

Photo by Lynn Betts, USDA, Natural Resources Conservation Service

tend to be high-cost, energy-intensive systems that are harsh on the environment. But in the last few years, there has been an increased interest worldwide in finishing livestock only on pasture or forage. Pasture finishing benefits the land, animals, and humans. The movement toward grass-fed foods, plus the desire to use earth-friendly techniques to grow forage and pasture, may compel the industry to adopt more sustainable practices.

Back to the Future in U.S. Forage Management

Global warming, desertification, soil erosion, flooding, and other ills can be reduced by holistically managing our forage and grasslands. Planned grazing, land management, and biological monitoring will lead us toward a healthier earth. The government (federal and state), universities, and citizens need to support this form of management.

We, the people, need to care for the earth. We need to move toward goals such as clean and plentiful water; fertile, vibrant, and productive soils; and an abundance and diversity of plants and animals. The choices we make need to promote these goals.

Industrialized agriculture has dominated recent times. The future could include a forage-based sustainable agriculture that would encourage

- increased soil organic matter and microbial life;
- decreased use of fossil fuels;
- sustainable nonpolluting capture of energy to feed the electrical grid for vehicles, engines, and housing, wind and tidal power, photovoltaic cells, hydrogen fuel cells, etc.;
- reduced use of toxic products;
- more locally grown food;

Photo courtesy of Matt A. Sanderson

- more soil protected with living cover;
- domestic animals and humans living in a more synergistic relationship; and
- greater diversity of plants and animals.

In the future, more lands need to be managed in accordance with a holistic grazing plan that includes animal impact. With modern electric fencing, virtual fencing or animal herding, the impact could be enhanced. Mob grazing (ultra-high stock density grazing) with attention paid to plant recovery before reentry, can heal the land, increase its capacity for self-renewal and make it more productive. Such systems can produce a greater diversity of adapted plants that will be nutritionally dense (offering more mineral and energy value). The forage can be harvested by a variety of domesticated and wild animals. Various multispecies grazing methods can be used. Strip grazing can increase utilization, production and performance. The animals produced in these systems can be harvested and used primarily for human consumption in the regional market. These farming and ranching options may be more attractive to beginning farmers and could entice them to return to the land.

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