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This is an invited article.

Abstract

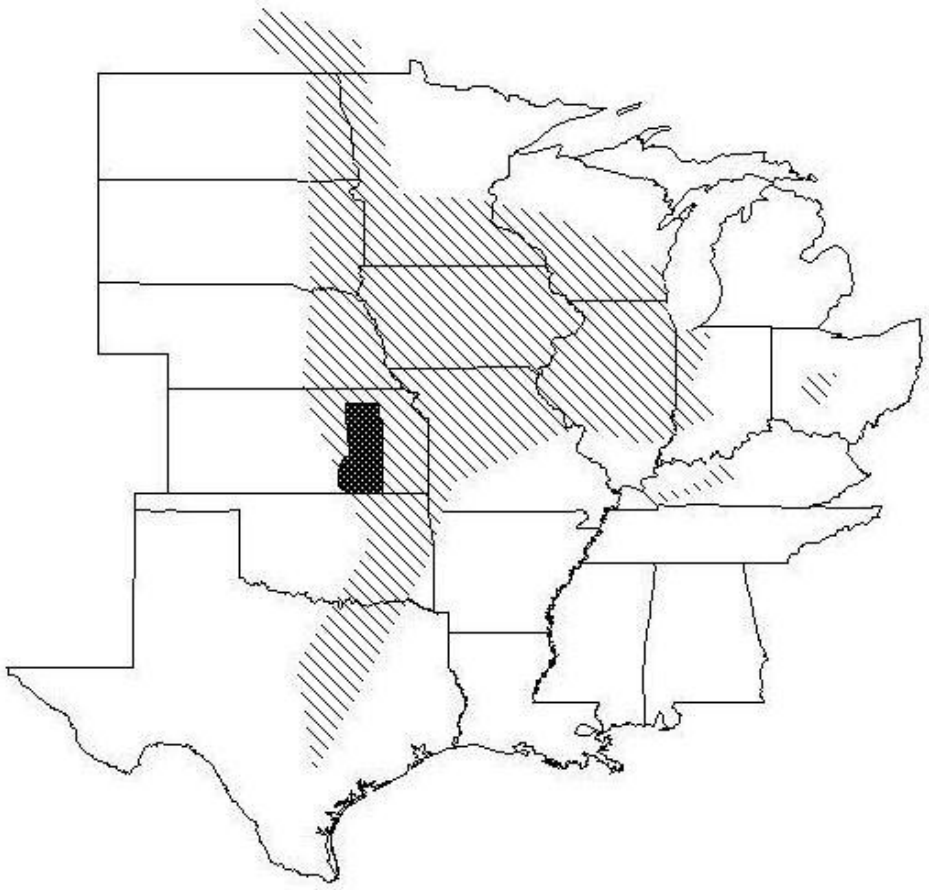
The tallgrass prairie has persisted in the Flint Hills of east-central Kansas for both biophysical and socioeconomic reasons, and has been one of the key elements in the development of the region. A population boom in the latter part of the 19th century and the subsequent increase in cattle in the 1860s-1870s were key factors in the transition of this landscape into a major cattle grazing region by the turn of the 20th century. At various points in the past 150 years, this social ecosystem has exhibited remarkable resilience in episodes of both drought and over-grazing. The resilience of the bluestem pastures had implications for stability in the rural economy. Yet, the land use regimes have undergone change since Euro-American arrival, thus the human signature on the land is by no means static. We approach the human-environment relationship as an ecological dialogue that includes both biophysical and social elements mutually shaping each other, and driven by human interests as much as biophysical factors. Current threats to the tallgrass prairie, including fragmentation and invasive species are discussed.

Introduction

The Flint Hills of east-central Kansas contain the largest remaining contiguous tract of unplowed tallgrass prairie in North America (Knapp and Seastedt 1998[1]). What remains today is a small fraction of the estimated pre-European extent of the tallgrass prairie that stretched across a substantial portion of what are now Illinois, northern Missouri, Iowa, southern Minnesota, and the eastern edges of the Dakotas, Nebraska, and Kansas (Figure 1). Before European immigration into the area, the region was home to various American Indian tribes, migrating buffalo, and other large ungulates that fed off the abundant grasses. The American Indians depended on the buffalo as a means of sustenance, and recognized that management of the grasses ensured their return in the spring. The prairie has persisted in the Flint Hills for both

biophysical and socioeconomic reasons, and has been one of the key elements in the development of the region. In addition to being steeply sloped in some places, much of the Flint Hills uplands are composed of shallow and rocky soils, which precluded plowing by early Euro-American settlers and their successors. Additionally, since the arrival of cattle in significant numbers in the 1860s-1870s, two key range-management practices, burning and grazing, have helped to maintain the structure and function of the tallgrass ecosystem. Yet, the land use regimes have undergone change since Euro-American arrival, thus the human signature on the land is by no means static.

Figure 1. Approximate Pre-European Extent of Tallgrass Prairie (Flint Hills Study Area in dark shade).



We approach the human-environment relationship as an ecological dialogue that includes both biophysical and social elements mutually shaping each other, and driven by human interests as much as biophysical factors**.** Viewing the Flint Hills environment as a social ecosystem allows for the recognition that American Indians and Euro-Americans brought different experiences, worldviews, and land use practices and therefore altered their environment in variant ways, creating different signatures on the land. At the same time, the biophysical elements of the environment shape society by providing opportunities, resources, and limitations, all of which are perceived differently depending on the mental models of the humans interacting with those

elements.

Scholars have conceptualized the study of society and environment in various ways, and researchers from various disciplines have grappled with this issue in recent years. Bell (2004[2]) has advanced the notion of ecological dialogue, which results in the continuous and mutual re-shaping of both the ideational and material. Worster (2003[3]) has emphasized the cultural element of the human-environment equation, arguing that an "economic culture" of entrepreneurialism and opportunism drove landowners to plow up millions of acres of grasslands in the 1910s and 1920s to sow wheat. Cronon (1983[4]) shows the mutual determination of environment and culture, and the different ways that humans live within and belong to ecosystems. Noorgaard (1994[5]) frames societies and environments as co-evolving systems in which the co-evolutionary process involves changing relations between components of those systems, and in which the systems themselves are in a constant process of change.

Scholars who have studied various aspects of the Flint Hills and the surrounding area have brought varying perspectives. Malin (1942[6]), Wibking (1963[7]), and Wood (1980[8]) draw on the notion of human adaptation to their biophysical environment. For Malin (1984[9]), newcomers to an ecosystem "experimented" with the environment, caused initial ecological disturbance, but then moved into a less destructive, exploitative stage. Wibking's (1963[10]) geography of the cattle industry in the Flint Hills is manifestly a story of an industry adapting to optimize its relationship with the environment. Similarly, Wood (1980[11]), writing from the perspective of the beef industry, describes the history of cattle in this region as a linear, uninterrupted march of progress. Kollmorgen (1969[12]) argued that a variety of geographic misconceptions on the part of "American woodsmen" of the frontier era led them to attempt to impose a small plot grain cropping system on western grasslands that led to destruction of forage. Worster (2003[13]), on the other hand, saw agricultural capitalism and the culture of entrepreneurialism as the force driving environmental maladaption in the Great Plains.

Two of the salient themes in this narrative are legacy and resilience. Big Bluestem and other tallgrasses and native grasses are the central legacy of the Flint Hills uplands. They are central to the prairie ecosystem of the region, as well as the agrarian and other human systems that have developed there. The grasses were the main source of food for the bison, which in turn were the center of the hunting and gathering societies of the region's Indian tribes. Similarly, the tallgrass prairie was the fertile ecological base for the later ranching systems of the Euro-American settlers who displaced the Indians.

The social legacies of the agrarian and other human systems established in the Flint Hills have had complex and contradictory relationships with the region's tallgrass prairie ecosystem. Human practices have sustained and threatened the viability of the region's ecosystem. Although the livelihood of the region's Indian tribes depended on sustaining the bison, Sherow (1992[14]) contends High Plains Indians had severely depleted the bison herds before the massive hunts by Euro-Americans, thus playing a role in the extirpation of bison. On the other hand, Euro-American ranchers, who have adopted sustainable practices such as spring burnings that benefit the tallgrass ecosystem, have also adopted agricultural practices such as double stocking that, if not done prudently could threaten the viability of the ecosystem.

More recently, there has been a trend of urban citizens moving into exurban and rural areas for a more "natural" living experience (Hoch 2000[15]). This urban-rural migration fragments the prairie by suppressing burnings, which eventually leads to a transformation of the landscape from one defined by grass species to one dominated by woody species (Briggs, Hoch and Johnson 2002[16]). A common theme throughout this narrative is the idea of legacy as an enduring quality to maintain the features of the tallgrass prairie. When elements contradict the goals of landscape conservation, this legacy is challenged and the prairie is threatened.

The second theme that emerges is the resiliency of the tallgrass prairie. At various points in the past 150 years, this social ecosystem has exhibited remarkable resilience in episodes of both drought and over-grazing. Moreover, at times when portions of the tallgrass prairie had been assumed dead, it proved also to have recuperative abilities when precipitation levels increased, and/or when grazing pressure was reduced. This resilience of the bluestem pastures, as part of a social ecosystem, also has implications for stability in some social patterns.

Description of the Region

The Kansas Flint Hills encompass more than 50,000 km^2 (Figure 2). The range of hills is about twenty miles wide; running north-south from near the Kansas-Nebraska border in the north to the Kansas-Oklahoma border in the south[1] (Figure 2). The Flint Hills region is predominately grassland, containing most of the approximate 1.6 million hectares of remaining native tallgrass prairie (Knapp and Seastedt 1998: 4[17]). The upland terrain is relatively steep-sloped and overlain by shallow, chert-bearing limestone soils unsuitable for cultivation. Several rivers drain the region. The largest is the Kansas River in the north; the larger river systems contain relatively flat and fertile bottomland that generally lack the shallow limestone on the surface and is primarily cropland.

Figure 2. Physiographic Characteristics of Kansas

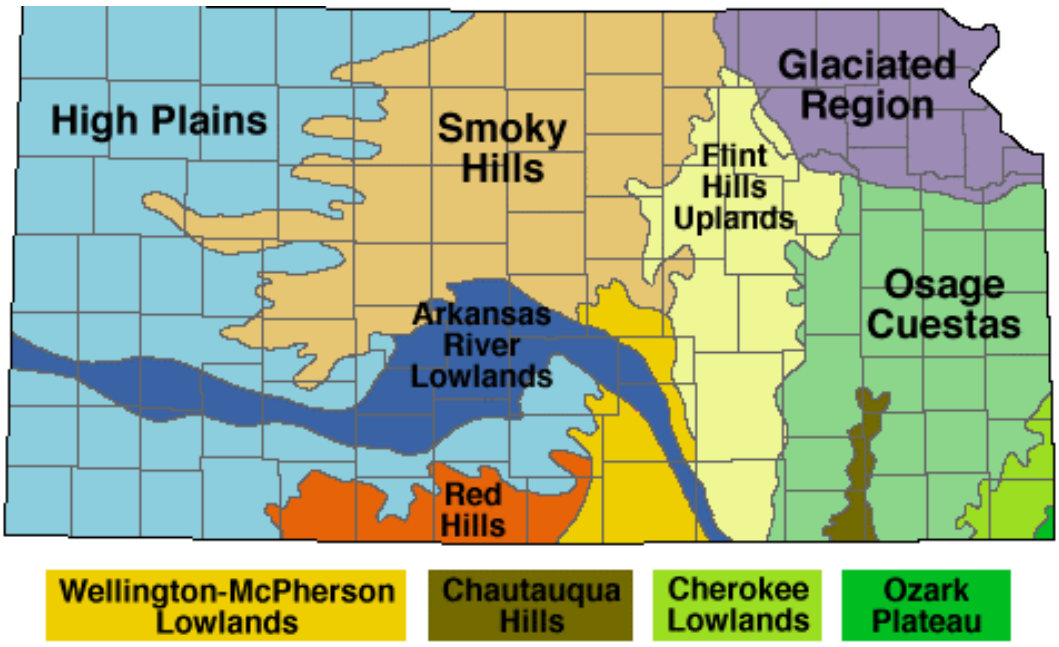
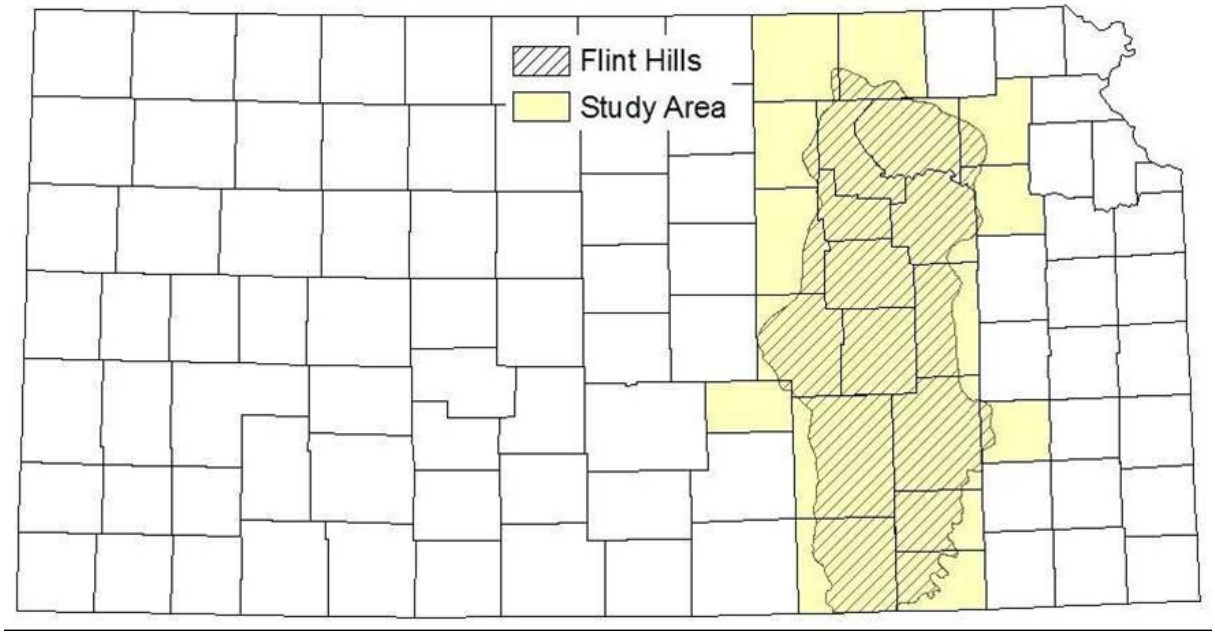


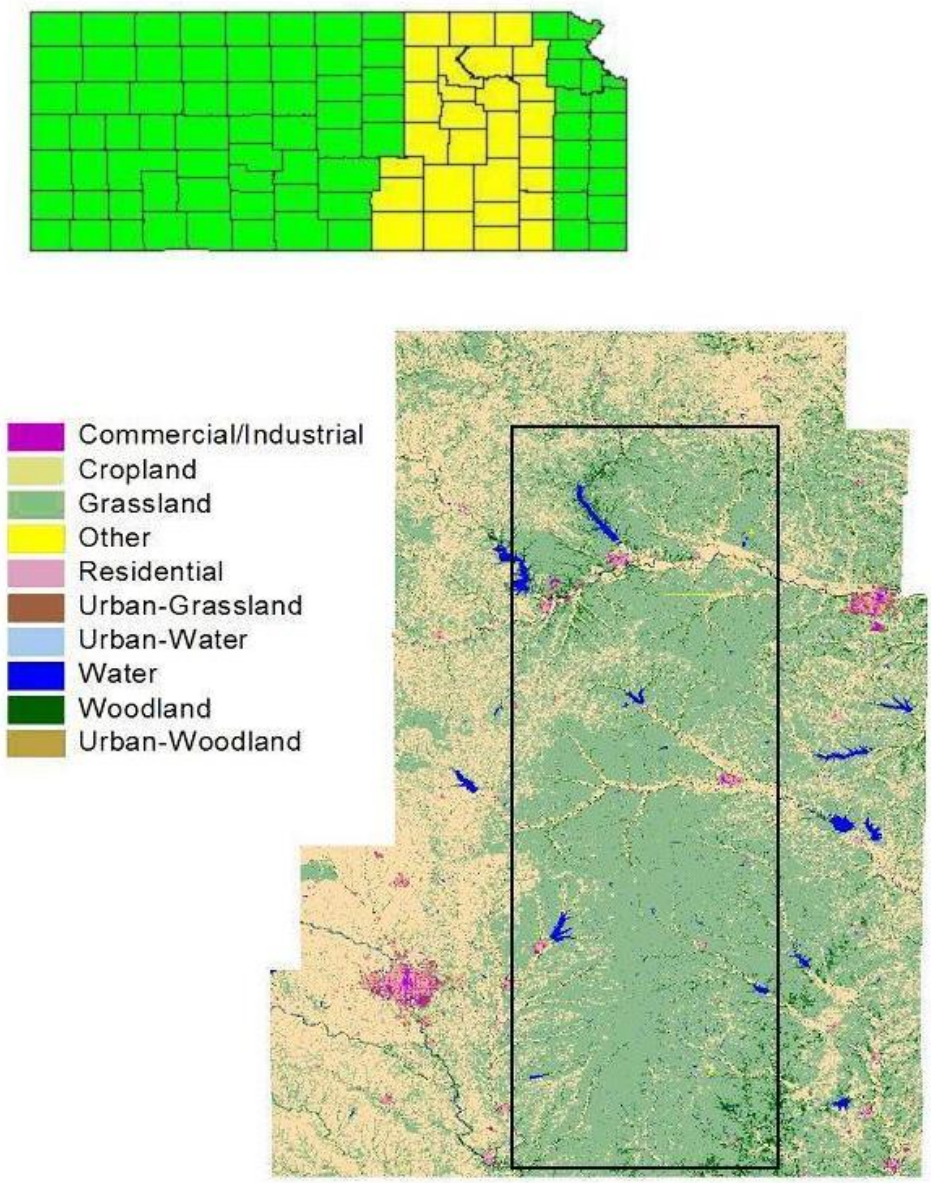
Figure 3. Flint Hills Tallgrass Prairie Study Area



Oviatt (1998[18]) has described the Flint Hills region as an "erosional landscape." These superficial, erosional processes are dynamic, with the rates and extent of erosion depending on climate, fire, and grazing regimes, as well as the time scale of interest. On the shortest time scales (decades to years), the main issue is erosion and steeply sloped hillsides and the sedimentation of stream channels.

Where streams dissect the hill slopes, creating upland riparian areas, woody species such as red cedar grow in some abundance. Various other tree species are also common as windbreaks for agricultural crops. The native bluestem pastures have survived in the Flint Hills because of the inability of early settlers to plow the sod of the uplands, or because of the marginal nature of upland cropping in areas they were able to plow. Limestone at or near the surface precluded cultivation, and played a key role in the social and ecological legacy of the region.

Figure 4. Land Cover in the Flint Hills and Surrounding Region (box approximates Flint Hills).



Map by authors. Data source: http://gisdasc.kgs.ku.edu

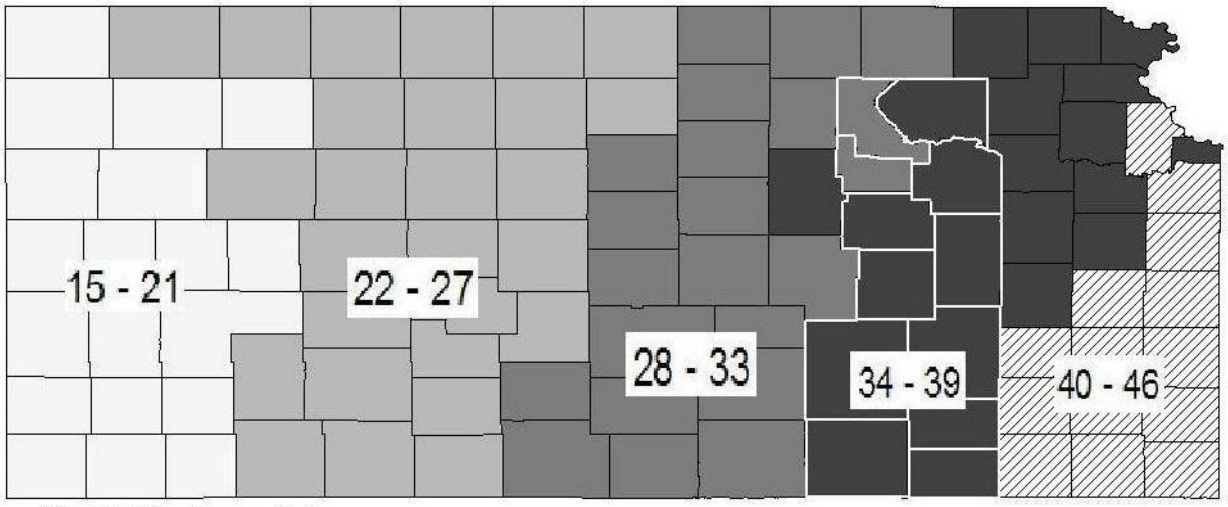
There are two main varieties of native bluestem: little bluestem (*Andropogon scoparius*) and big bluestem (*Andropogon furcatus*). The growing season for the bluestem is approximately 180 days, from late April to late October. Peak growth is during May and June, after which the grasses begin to die off in early July when precipitation drops off and temperatures increase. The bluestem is the predominant species of the Flint Hills for a number of reasons (Reichman 1987[19]). First, the limestone surface of the area allows water to percolate often to more than twelve feet below the surface, which the roots of the bluestem can reach. Second, the above

ground biomass from previous seasons decomposes to provide nutrients for growth in subsequent seasons. Likewise, the storage of rhizomes under the surface helps to stimulate new growth. Third, the bluestem grows in high density and towers above other varieties of grass, allowing it to crowd out competing species. Big bluestem can reach a height of more than three meters in the most productive years; although because of fire and grazing regimes this is uncommon (Reichman 1987[20]).

Finally, three key processes regulate and sustain the tallgrass prairie – the variable, continental climate, periodic fire, and ungulate grazing. Each of these elements is fundamental to the structure and function of the tallgrass ecosystem and protects it by eliminating the threat of succession to a landscape dominated by wooded species. The climate[2] of the Flint Hills is temperate, mid-continental (Borchert 1950[21]). The Flint Hills of eastern Kansas receive greater precipitation than places farther west due to air masses bringing moisture directly northward from the Gulf of Mexico (Figure 5). Precipitation during the spring and early summer averages about 114 mm, and marks the most important time for growth of the bluestem grasses. During dry months, precipitation can be less than 25 mm, while at the other extreme, intense rainfall of 100 mm or more per hour often floods the bottomlands. The yearly mean temperature is 13C, but considerable interannual variation produces a range from 6 to 19C (Figure 6).

Fire is an essential element in the legacy of the tallgrass ecosystem (Borchert 1950[22]; Ohlenbusch and Hartnett 2001[23]; Hoch 2000[24]; Reichman 1987[25]; Owensby et al. 1973[26]; Aldous 1934[27]). Whether through lightening strikes or planned burning regimes, fire eliminates debris and competitor species (Pyne 1984[28]). American Indians were the first to regularly burn the prairie for many reasons; and among them, they found that burned areas grew much greener and attracted bison (Aldous 1934[29]; Pyne 1984[30]; Sauer 1975[31]; Unrau 1971[32]).

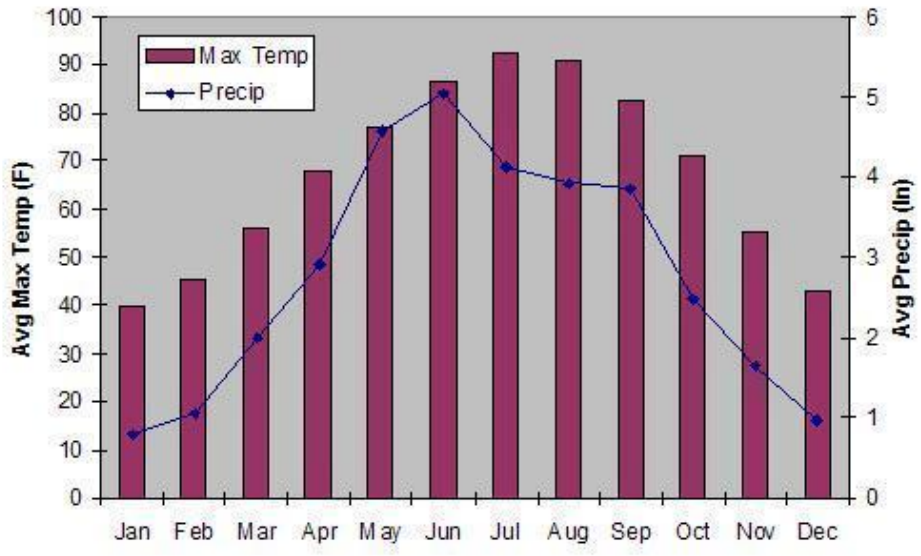
Figure 5. Average Annual Precipitation in Kansas in inches



*Note: Flint Hills study area outlined

Map by authors. Data from the High Plains Regional Climate Center: http://www.hprcc.unl.edu/index.html

Figure 6. Average Maximum Temperature and Precipitation: Manhattan, KS (1900-2004)



Map by authors. Data from the High Plains Regional Climate Center: http://www.hprcc.unl.edu/index.html

The settlers' early adoption of regular burning as a management practice was mixed (Hoy 1989[33]). Some early settlers who profited from the growing cattle trade in the late nineteenth century acquired techniques for controlled burning from local American Indians. However, without roads or other boundaries for containment, burning often got out of control, causing problems for non-practicing neighbors. While some opposed to burning believed it would turn the land infertile, others held a view that the tallgrass landscape was inferior to areas east, wanting to replicate in Kansas the more forested environment they had previously lived in. Through time though, nearly all ranchers in the Flint Hills adopted widespread regular burning. Eventually, Kansas State University (the state land grant university) research supported the practice, though it remained controversial (Aldous 1934[34]). Prescribed burning continues in the Flint Hills, starting anywhere from mid-March and lasting through late-April. Although not all ranchers and operators burn every acre of land every year, most practice some regular routine of burning at intervals of one to four years. A continuing legacy of prescribed burning for the management of the tallgrass prairie is essential, and factors affecting its continuation will undoubtedly have effects on the structure and function of the regional ecosystem. Reportedly, prescribed burning improves grazing distributions, reduces litter, recycles nutrients, and controls woody species (Ohlenbusch and Hartnett 2001[35]). Indeed, the elimination of woody species is a major goal of prescribed burning (Owensby et al. 1973[36]).

Grazing by ungulates is the third essential element in the tallgrass prairie. Although bison and other animals like antelope adequately grazed the prairie, very few of these animals remain on the prairie today. Before the near extirpation of the plains buffalo (*Bos bison*) in the nineteenth century, that species played a key role in the Great Plains (Knapp et al. 1999[37]). During the Euro-American settlement period and extension of railroads, the bison population was reduced to mere thousands. Since then, owners and operators of the region have replicated the natural

disturbance elements of the prairie through agricultural practices (burning and grazing) geared towards cattle ranching. Both American Indians and Euro-Americans adapted practices involving fire and grazing, thus engaging in close interactions and processes that simultaneously shaped both their societies and the ecosystem.

Historical Land Use Patterns

Following Wibking (1963[38]), the historical development of the Flint Hills can be divided into the period of American Indian influence, the General Farming Period from 1854-1880, and a post-1880s ranching period, each of which is characterized by a different land utilization emphasis. Historians believe the first known settlement in the Flint Hills region was of the Kansa (the Konza or Kaw) Indians near the mouth of the Kansas River. The Kansa, and other Indians of the region, left their signature on the landscape.

The Kansa were semi-nomadic; their culture was local resource dependent with adaptive practices, planting corn, squash, and beans in small plots in the bottomlands. Bison meat was the most important animal protein in their diet, which they supplemented with elk and deer. The bison hunt was a tradition undertaken twice a year in Kansa society. The hunt, as well as the preparations concerned with its success, were well entrenched in Kansa culture. Burning the prairie was one of those preparations. The Kansa had learned that burning mattered, and they used fire strategically. For the Kansa, burning was a ceremonial practice with a two-fold purpose: as a call for rain, and to attract bison to the succulent grasses that emerged afterwards. Part of the Kansa legacy in the Flint Hills was to perpetuate the structure and function of the tallgrass prairie, in part by using fire to forestall succession to woody species.

The agricultural development of the Flint Hills during the second half of the nineteenth century was significantly influenced by social policy that promoted Euro-American settlement. The Kansas/Nebraska Act of 1854 established Kansas as a US territory and opened its land to claims by US citizens. In 1862, the US Congress passed three bills: The Homestead Act, the Pacific Railroad Act, and the Morrill Acts of 1862. Each contributed to the agricultural transformation of the newly incorporated frontier. The Homestead Act encouraged the population of the plains by providing 160 acres of land to private individuals and allowing them to secure title to the land after five consecutive years of improvement.

The Pacific Railroad Act allotted large amounts of land to railroad companies for infrastructure development. In 1863 the Atchison, Topeka, and Santa Fe (ATSF) Railroad received one such grant that extended from the Missouri River to the Colorado state line (Bryant 1974[39]). By 1870, the ATSF rail line had reached Emporia in the eastern Flint Hills. These rail lines were important developments in enabling the movement of cattle through and from the region, and precipitated a three-fold increase in population, and more than a four-fold increase in the number of farms in the region.

Finally, the Morrill Acts of 1862 and 1890, the Hatch Act of 1887, and the Smith-Lever Act of 1914 respectively formed the legislative foundation of the land-grant college complex for teaching, research, and extension. The rationale behind the land grant system was that once

settlers arrived the college would provide them the institutional support they would need to be productive on the land. Later the Smith-Lever Act would provide funding for county extension agents who were charged with transferring science-based information to agriculturalists and their families.

The General Farming Period began just after Kansas organized into a territory in 1854. Settlers from Ohio and Indiana began to move in rapidly, typically settling in the bottomlands along rivers first, then in the uplands, which they could purchase from railroads. By 1860, the population of the Kansas Territory grew from 8,500 to almost 100,000 (Unrau 1971: 70[40]). These new settlers cropped corn in the bottomlands and small grains in the uplands, as well as some hay for cattle. Additionally, many had some livestock such as cattle, hogs, and sheep. In this period according to Wibking (1963[41]), settlers "experimented" with the land in order to ascertain what crops, tools, and practices would prove successful.

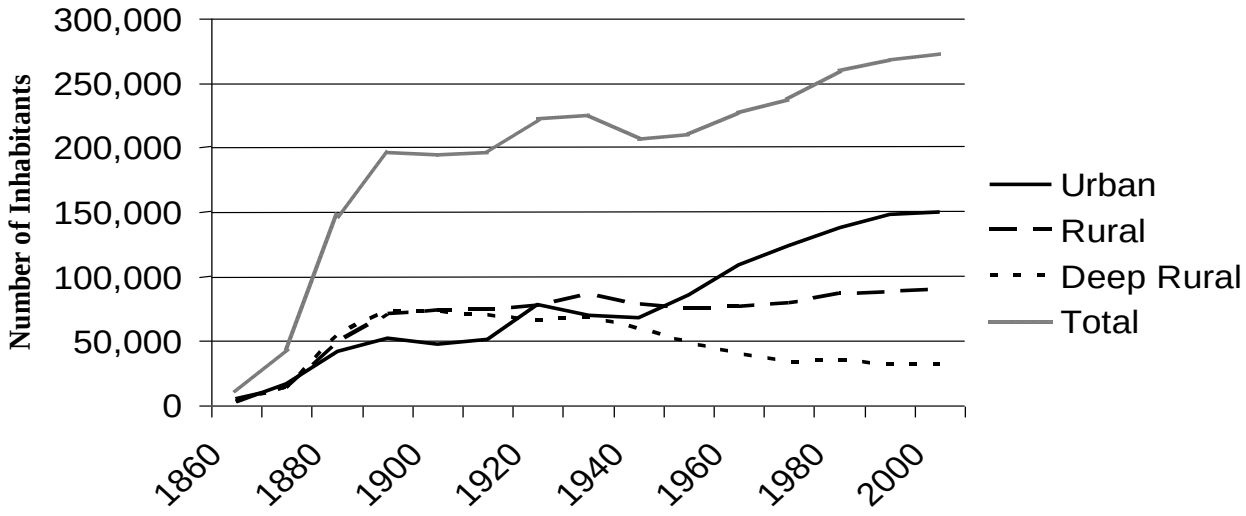
A new wave of immigrants settled in the area after 1870, some establishing operations in the uplands where land was more plentiful. Isern (1985[42]) argues that upland farmers succeeded through their limited grazing and social ties with bottomland farmers. The passage of herd laws in some Flint Hills counties established bans on transitory cattle. One of the challenges of the time was keeping free-range livestock from destroying fields and gardens. Before the introduction of barbed wire, farmers relied on board or stone fences, or had to maintain hedge. These options were either time consuming or costly to establish and maintain. Growing adequate hedges could take several years and timber in the uplands for fencing was scarce.

After the enactment of herd laws, there was a perception that the uplands would always be publicly available for cattle. These free-range areas would disappear in only ten years, after barbed wire made fencing pastures cheap and efficient. By 1880 general farming had declined significantly in the region, and began to give way to large scale ranching. Many small farmers did not want or were not able to acquire large tracts of upland area. They viewed the uplands as unimportant because of their lower value for cropping and because they often assumed the uplands would remain open range. Moreover, the purchase of large tracts of upland pasture required capital, some of which came in with new settlers (Paul 1998[43]). Those with the capital were able to accumulate large amounts of pasture grass through their ability to acquire land from the railroads. Once barbed wire became available, the free range was fenced in, and small farmers had neither room to expand, nor access to grazing land (Wibking 1963[44]).

The final blow for small farmers were droughts in the 1880s, which forced many of them to sell to expanding ranchers, who were accumulating land in bottomlands and uplands and combining them into larger holdings (Wibking 1963[45]). Yet, despite the decline in small farms, throughout the next ten years the region as a whole grew in population by nearly fourfold (Figure 7). By 1870, the number of inhabitants had grown to 43,918, and the number of farms to 4,941. The 1880 census recorded 147,569 people and 19,911 farms. Thus, in spite of the transition away from general farming and toward ranching as the predominant land use pattern, the region as a whole was growing rapidly. Moreover, it is clear that the numbers of people and farms were now well beyond the levels of the Kansa Indians. This means the landscape was undergoing change as more bottomland was broken out for crops, and upland prairie quickly moved toward private enclosure, and acquired the rectangular, checkerboard pattern of the Homestead Act,

delineated by the paths of barbed wire fencing.

Figure 7. Population in the Flint Hills (1860-2000)



During this same period, the slaughter of migrating buffalo herds in the plains of Kansas and other prairie states was well underway. The precipitous decline of buffalo herds and the concomitant rise of available transportation networks allowed for a rapid transformation of the region towards agriculture that focused on the cattle industry. Growth of the Kansas City cattle market accelerated in 1855 when the Missouri legislature enacted a ban on Texas cattle during the summer months. The ban was in response to concern about Texas Fever, a disease spread by ticks carried on Texas cattle. Longhorn cattle were immune, but domesticated English stock was extremely susceptible to the deadly disease. Thousands of cattle died in Missouri and Kansas, and Kansas enacted its first quarantine law 1859 to enforce a ban between June and November on Texas, Arkansas, and Indian stock. Although quarantine laws and onset of the Civil War temporarily brought an end to the cattle drives (Gard 1954[46]), after the war Texas cowboys rounded up their herds and were ready to drive them to market. A revision to the Kansas quarantine laws in 1867 guaranteed, under certain circumstances, reimbursement for death of local cattle, which allowed Texas drovers to enter Kansas from the southwest. The Union Pacific had built west of St. Louis and Kansas City, which made the drive north shorter and hopefully more profitable. Malin (1942[47]) notes that although quarantine laws prevented Texas cattle from traveling through the Flint Hills, drovers continually ignored those laws.

The ticks that spread Texas Fever were not a factor in the winter, and because quarantine laws did not apply between November and April, some cattle were wintered on local pastures, which included Flint Hills bluestem. This wintering process would continue in the Flint Hills despite the end of Abilene as a cattle nexus in 1872. Settlers also found that the bluestem pastures were resilient to periods of extreme drought, allowing them to graze cattle in the Flint Hills when it would not be possible elsewhere (Wood 1980[48]). Ranchers drove their cattle to the Flint Hills

for finishing, making the Flint Hills region a transitory point for cattle brought from Texas and other southwestern states. The combination of rich upland grasses, fertile bottomlands for grains, sufficient rain, and railroads provided the key elements for the development of an agricultural economy in the region geared to cattle production and establishment of a culture that recognized the Flint Hills as an important region for grazing transient cattle.

The rapid diffusion of barbed wire in the 1880s transformed the Flint Hills from a commons grazing area to large tracts of privately held, fenced land in a span of a few years (Niles-Beattie 1996[49]). This transference of public grazing land to private owners in the Flint Hills signaled a growing distinction along the lines of geography, land use, and ownership. The availability of cheap and low-maintenance barbed wire fencing did away with the need for herd laws and common areas and allowed for the settlement and eventual grazing of upland prairie pasture. Before 1882, Chase County was essentially unfenced and bottomland farmers grazed the uplands with ease and little cost. Just two years later, barbed wire enclosed all grassland in the county and nearly four million acres within the bluestem region had become cattle country (Hilton 1929[50]).

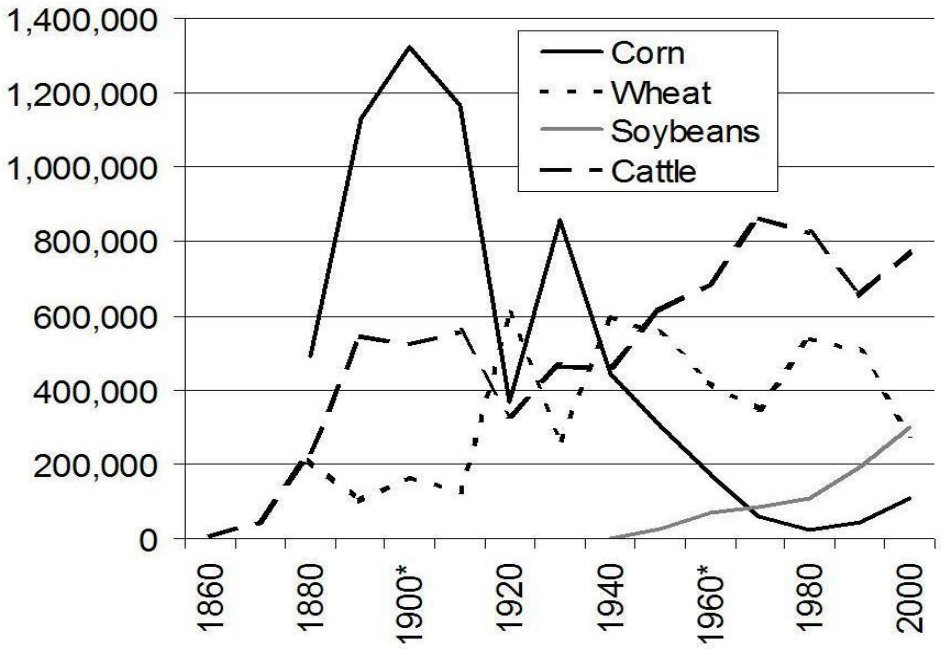
Following enclosure, growth in the Flint Hills cattle industry came from two general directions. One was the continuance of the transitory cattle system that now relied on the railroads for cattle in-shipments, rather than overland trail routes. The second development was the breeding of purebred stock year-round, brought in by immigrant settlers (Wood 1980[51]). Cattle inventories (other than milk cows) for the Flint Hills after 1860 showed a remarkable increase from just 5,781 in 1860 to more than 231,000 in 1880, and in the 1890 census, to 545,673. The number of farms in each county illustrates the differences between the Flint Hills counties in relation to cattle inventories and geographic characteristics. For instance in 1890, Cowley County had the least amount of upland grass (6%) according to government surveys, and correspondingly the lowest ratio of cattle to farms (14:1). On the other hand, Chase County led the region in upland grass (88%) and had an average of sixty-six to one cattle to farm ratio. This ratio is more than double the next closest county, as all others in the region range from approximately sixteen to one to thirty-two to one (16:1 – 32:1).

The terms of ownership also developed according to geographic distinctions: the bottomlands were typically smaller and owner-operated, while large urban-owned, leased arrangements distinguished the uplands. Many small farmers who believed grazing lands would always be available, or those unable to buy pastureland either "made individual accommodations" (Isern 1985:264[52]), or were "forced to sell out" (Malin 1942:12[53]). The new settlers succeeded with cattle on the uplands, and again the result was a clear distinction: the bottomlands were cropland, while the uplands were prairie pastureland. Pastureland required little care and was resilient to most disturbances. Given this, according to Kollmorgen and Simonett (1965: 278[54]) "many of the absentee urban owners find no urgent reason to visit their holdings for periods of years."

The latter decades of the nineteenth century were generally a boom period for the Flint Hills. The number of farms in the region increased dramatically, from about 1,500 farms in 1860 to more than 25,000 in 1900, expanding acres farmland from about 250,000 in 1860 to more than 6.2 million acres in 1900. The average farm size increased from about 158 acres in 1880 to 256 acres in 1900.

Corn and wheat were two key crops during the period 1860-1900, though some hay, oats, and other minor crops were also grown. The expansion of corn acreage can be attributed to the growth of the population and number of farms planting corn for human consumption, but also corn was grown extensively as feed for cattle during the winter months. The number of cattle in the region grew rapidly, from about 6,000 in 1860 to more than half a million head in 1900. Thus, the area experienced a decline in general farming but an increase in farming focused on corn for cattle feed, the raising of fine, registered stock, and the grazing of transient cattle during the summer months. Many operations engaged in more than one of these activities at the same time; for instance, many ranchers also had some cropland to raise hay and grains for stock during the winter.

Figure 8. Selected Crops (in acres harvested), and Inventory of Cattle in the Flint Hills, 1860-2000.



Note: 1900 data from KS Board of Ag. 1960 data from 1959 census.
Source: US Census and Census of Agriculture

By 1900, the Flint Hills had become best known for its nutrient-rich grasses, and the grazing of transient cattle was established as a major business of the region. The transient cattle system was deceptively simple. In April and May, as the bluestem pastures begin to green up, ranchers shipped in their cattle and put them out on the pastures to graze. The protein levels of the grass, which begins to drop off by July, determines the length of the grazing season. During the grazing season – in the herds of the late nineteenth century – cattle would gain 200-300 pounds on grass alone. The original longhorns from the southwest were less efficient at converting grass to body weight. In the 1890s, ranchers began improving their herds by bringing in purebred Shorthorns, Angus, and Herefords from England and Scotland. With time, the herds were bred for more efficient and rapid weight gain, laying on meat faster than unimproved herds thus saving feeding costs. Purebreds would mature in three years weighing 1,500-1,700 pounds,

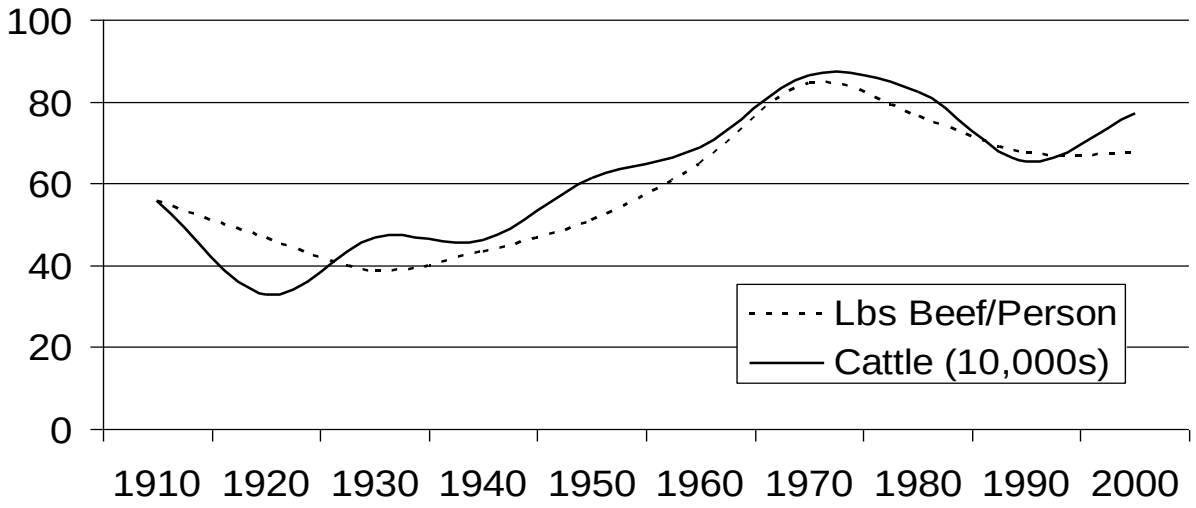
which was 500-600 pounds heavier than their "unimproved" counterparts were at the same age (Wood 1980[55]). This of course meant more profitability for ranchers, and the possibility of increasing beef production without necessarily increasing land holdings. As Wood (1980: 42[56]) notes, "This blooded stock had begun to work its magic on the range as more and better beef was being produced in a shorter period of time from fewer cattle and on fewer acres of land."

Thus, a rather stable and resilient land use pattern became established in the Flint Hills – summer grazing of transient cattle plus over wintering on grains and hay produced on the cropland. Scholars have noted the stability of the grazing system of the Flint Hills. While cropping systems are more vulnerable to periods of drought, the Flint Hills grasses helped to stabilize the beef industry in Kansas and the Southwest in times of severe drought (Wood 1980[57]). Indeed, prolonged droughts drove the concentration of cattle in the Flint Hills. The region's limestone soils hold water and the bluestem's deep root system allow it to reach that water in exceptionally dry periods. In turn, during drought periods, this allows herds to survive on the tallgrass where other grazing areas (e.g., shortgrass prairie) would not sustain them. As a long-time rancher near Council Grove put it some years ago, "Flint rock pastures absorb the rainfall in the spring and then give it back in the heat of the summer" (quoted in Wood 1980: 9[58]). By the end of the nineteenth century, raising cattle in Kansas had largely completed its transition from a frontier institution to a ranching industry. This basic pattern of land use in the Flint Hills would remain relatively stable over the next century.

In the first two decades of the twentieth century, well into the post 1880s ranching period, agriculturalists in the Flint Hills saw increased demand for feed grains, forages, and beef, which pushed prices and land values up and increased the equity and borrowing capacity of farmers and ranchers in the region. Along with the growing US population, the advent of World War I further drove demand, as wheat and beef exports to Europe increased. By this time, American farmers and rural areas were well integrated into an international economy, responding to demand and prices in markets outside the United States. Wheat farmers rapidly expanded the number of acres devoted to wheat by converting corn acreage and bringing more grazing land under tillage. The increased wheat acreage expanded production more than threefold; acres harvested in the Flint Hills went from 167,000 in 1900 to about 606,000 acres harvested in 1920. Wheat surpassed corn in acres harvested by 1920, and that year the harvest of the two crops combined equaled nearly a million acres.

Higher crop prices also meant that cattle feed for over-wintering had become more expensive. Given that the prices of beef were also on the rise, there was also upward pressure on land values, and the price of both renting and purchasing pasture was increasing. The cost of renting grass (pasture) increased from $1.00 per head for six months of grazing to as high as $20 per head by 1918, reflecting higher beef prices (Wood 1980[59]). Throughout the same period, the price to purchase pasture went from about $3.25 an acre to roughly $48 an acre (estimated from Wood 1980). Yet, pasture was in great demand. Even though per capita beef consumption in the United States was on the decline in this period (Figure 9), a growing overall US population plus increased demand from Europe meant that overall demand for beef was increasing. Malin (1942[60]) estimated the number of transient cattle grazed in the Flint Hills to be between 213,000-319,000 annually in the early 1900s, and somewhat higher during the war years.

Figure 9. Per Capita US Beef Consumption and Flint Hills Cattle Inventory.



Source: USDA

The number of acres of farmland expanded rapidly from 1860 to 1900 then remained rather stable through 1950. Thus, there were no more acres being entered into farms after 1900. From 1900 to 1920, the number of farms in the region decreased by almost 4,000, but farm size increased to 270 acres in 1920. Rural population declined along with farm numbers. The total population in the Flint Hills peaked in 1890, remained at that plateau until 1910, then jumped to about 221,000. Much of this increase was the increase in urban population between 1910 and 1920, in part due to higher urban wages relative to rural. Along with the decline in the number of farms was a net decline in the rural population. The rural population during this same period was relatively flat, with a slight decline in the deep rural population (i.e., non-metro and non-adjacent to a metro county).

As mentioned above, WWI had created substantial demand for American wheat as Europe turned to the United States to meet its grain needs. In addition to gains through varietal improvements, one of the primary means for increasing wheat production was to bring more land under tillage. Low cattle prices added to the incentive to increase land in wheat and reduce emphasis on cattle. Between 1914 and 1919, farmers plowed up 11 million acres of native grasslands in Kansas, Colorado, Nebraska, Oklahoma, and Texas (Worster 2003: 324[61]). Converting grazing land to cropland continued through the 1920s as farmers became further integrated into the international economy. Thus, when the severe and prolonged droughts of the 1930s hit the Great Plains, it meant that large expanses of open, flat croplands were exposed with little or no vegetative cover, thereby providing the conditions for the dramatic Dust Bowl storms.

The conditions in the Great Plains had implications for land use in the Flint Hills. For one, much of the mixed and short grasses of western Kansas and other plains states had been converted to cropland, thereby reducing the supply of grass and forages in the west. Moreover, the droughts also meant that the remaining mixed- and shortgrass prairie could no longer support large

numbers of cattle because of its compromised condition. Thus, during the drought years, ranchers shipped cattle into the Flint Hills from western Kansas and other adjacent areas of the Great Plains to save herds, especially if they had valuable breeding stock they wanted to save (Wood 1980[62]). Many less valuable drought stricken cattle were sent to market or butchered locally to minimize losses and reduce suffering. In spite of the prolonged droughts, there was pasture available in the Flint Hills, because of the relatively greater precipitation and the deep and extensive root system of the bluestem grasses, and its ability to access water well below the surface. The tallgrass prairie ecosystem was thus more resilient than other grasslands and cropland in periods of severe, prolonged drought.

The heavy use of the Flint Hills pastures during the drought years led in turn to great concern about overgrazing and the depletion of rangelands in the region. Professor A. E. Aldous of Kansas State College (a KSU precursor) noted in May of 1935 that at the turn of the century, grazing capacity in the Flint Hills pastures was about three acres per head, or about "thirty to forty per cent greater than they have at present" (Aldous 1935: 3[63]). Moreover, he documented other serious signs of pasture degradation, including deep ditches cut from increased run-off "due to close cropping of vegetation." He also expressed some optimism, however, because examination of samples of bluestem grass roots showed that some of the root system was alive when the plant had appeared dead.

Anderson (1940[64]), an agronomist for the Kansas Agricultural Experiment Station, also showed that overgrazing and drought had depleted the grazing capacity of bluestem pastures. His data showed that in 1900 bluestem pastures could be stocked at a rate of about two acres of grass per head (mature cow or steer) per grazing season. By 1933, the same animal needed an average of five acres of grass, and seven acres by 1940, ten acres on some severely depleted pastures (Anderson 1940: 5[65]). He also pointed out that pastures weakened by over-grazing and drought also become susceptible to weed invasions. Both Aldous (1934[66], 1935[67]) and Anderson (1940[68]) argued for deferred grazing strategies as a way to utilize forage without injuring the pasture. The general thrust of the idea was protection of the pasture. Grazing would be deferred for about six weeks, allowing enough early spring growth to enable the grass to withstand close grazing for the remainder of the season.

Range depletion and the attendant soil erosion were major concerns at the time. An entire 1946 *Report of the Kansas State Board of Agriculture* was devoted to the topic of "Soil Conservation in Kansas." It contained articles addressing the issue in cropland as well as range and pasturelands. In the report, Anderson reviews the damage of the 1930s, noting that:

> Many [pastures], once thought to be destroyed, now have a cover of grass nearly equal to that before the dry years" (1946: 93[69]), both confirming the degradation during the 1930s, but also suggesting that with time, resumed precipitation and conservation measures (deferred grazing, burning when grass crowns were wet to minimize burn damage, etc.), pastures could recover from severe depletion.

Debate continued about how much of the range depletion could be attributed to over-grazing and how much attributed to drought. Some (e.g., Malin 1942[70]; Wood 1980[71]) tended to dismiss the argument that it was land use practices (i.e., over-grazing managed by ranchers and pasturemen),

and emphasized that the bluestem pastures would recover with increased precipitation. Others, such as the Kansas State College researchers, were clear about the negative impacts of over-grazing, and argued for ameliorative strategies.

Although the agricultural economy was generally depressed during this period, beef producers generally fared better than those who relied heavily on crops. The relative resilience of the bluestem pastures to drought provided some economic resilience to the region as well. While some producers in western Kansas became wealthy during the wheat boom of the war period, this also created conditions of overproduction post war, and wheat prices tumbled during the 1920s. The depression forced many farmers out of business, a fact reflected in the loss of nearly one thousand farms in the Flint Hills between 1920 and 1925. Interestingly, however, the number of farms increases somewhat between 1925 and 1935, back up to 22,000, before resuming its century-long decline. This ten-year cessation of the decline in farm numbers may well be linked to the resilience provided by the relatively drought resistant bluestem pastures. Moreover, average farm size grew gradually during this period – from 270 to 325 acres – then surged after 1940, more than doubling in four decades. As the depression forced smaller ranchers out of business, many ranchers and ranch-farm operations took the opportunity to expand their operations (Wood 1980[72]).

The Post-War Period

Transitions in the Flint Hills during the post-war period were linked to the rapid structural changes in the commercial feedlot and meatpacking industries, which in turn were shaped by larger structural changes in the political economy of the post-war (Fordist) agrifood system. The per capita beef consumption in the United States nearly doubled from about forty-three pounds in 1940 to more than eighty-four pounds per capita in 1970 (Figure 9). Interestingly, the local cattle inventory in the Flint Hills nearly doubled as well from 1940 to 1970. It dipped between 1970 and 1990, but began to rise again in 2000. It appears that the cattle inventory in the Flint Hills tracks closely with the trends in per capita beef consumption in the United States. Thus, it seems this particular landscape has developed a niche role in the industry, primarily by focusing on its uniqueness vis-à-vis the bluestem tallgrasses. The increase in the year-around cattle inventory suggests that the region has developed two primary roles, that of cow-calf operations and herds that sell breeding stock. In both cases, the weight gains on the bluestem pastures are the basic element of the agricultural economy of the region.

Wibking's (1963[73]) general characterization of land use in the Flint Hills seems to hold through the post war era, with some modifications. The southern third of the Flint Hills emphasizes cow herd production, having greater numbers of over-winter cattle and relatively less transient cattle. The center third, which includes the large absentee-owned pastures of Chase County, emphasizes transient grazing with a focus now on producing young cattle destined for feedlot finishing. The northern third, where there is a fair amount of bottomland along the Kansas River, emphasizes livestock-farm operations.

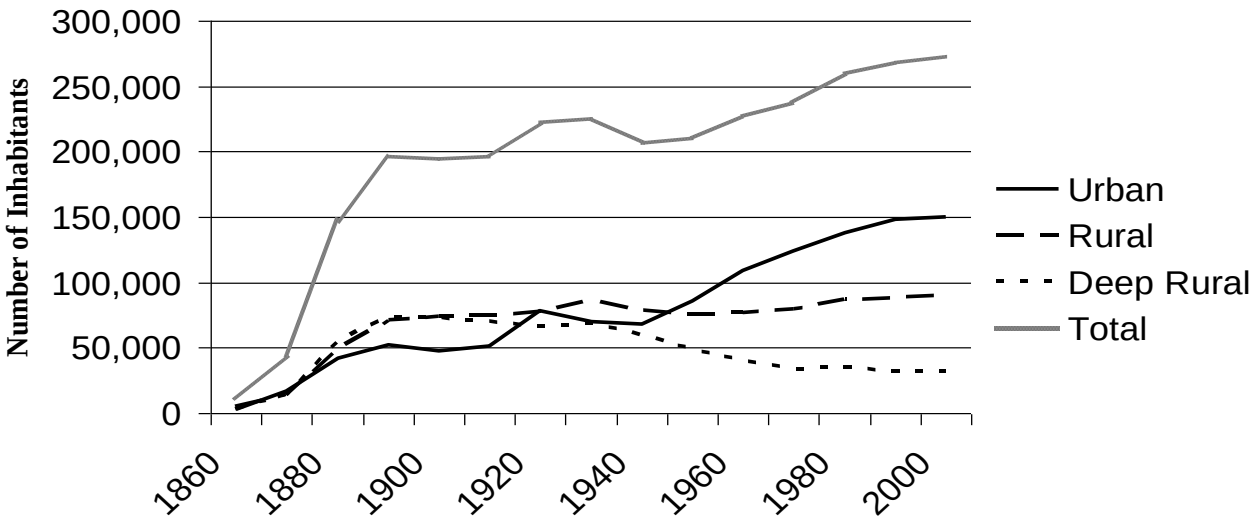
In terms of cropping, corn production declined throughout the post war period, although some corn is still grown for local feeding operations. Wheat is still grown in the region as a cash crop,

although the number of acres harvested wheat has been in decline since 1980. In 1940, soybean production began to appear in the data. The acres of soybeans harvested increased steadily until 2000, at which point is became the most harvested crop in the Flint Hills; soybeans are important in the livestock-grain complex and as a cash crop.

An interesting population dynamic in the Flint Hills post 1940 is the contrary trend of population between urban counties and those we identify as deep rural counties. The region as a whole has generally experienced a population increase throughout the study period (Figure 10). Yet, a county-by-county review shows that the increase of population is due to increases in just three counties. The three urban counties show growth occurring primarily after WWII. And after 1970, the population of these counties outnumbers that of the other nine combined. The urban areas are developing as regional trade centers and metropolitan areas, while the deep rural areas continue to experience population decline. Population increases in the urban counties are of special interest to conservationists because of the impact that those social dynamics have on the landscape.

Conservation in the Flint Hills has taken on the short-term goal of preserving land in both the form of a publicly available national park, and in the shape of a university-run research station. Scientists are concerned about the long-term effects of biodiversity loss through landscape transformation by competitor species. The advance of two species currently threatens the tallgrass legacy: sericea lespedeza – a legume that has invasive characteristics (Fechter 2000[74]) – and red cedar, a woody species that expands in grassland prairie after suppression of fire (Hoch 2000[75]). Combined, the two species currently represent serious threats to the tallgrass region.

Figure 10. Population in the Flint Hills (1869-2000)



Woody species, such as the red cedar (*Juniperus virginiana*), have been substantially increasing in population in the Flint Hills since around 1970 (Owensby et al. 1973[76]). Researchers have shown that the increase in woody species is a result of disruption in the application of fire, which in turn relate to population growth and resultant land fragmentation (Hoch 2000[77]). Most of the

population growth in the Flint Hills has occurred in the more urbanized counties, a phenomenon that Hoch (2000[78]) identified as a predictor for woody species growth. His analysis found a strong relationship between population change after 1970 and woody species growth during the period. Hoch traced several explanations of the increase in woody species, and found that while the suppression of fire was the primary determinant, a gradual increase in housing starts around Manhattan led to fragmentation. Fragmentation around the urban fringe appeared in the form of a matrix of rangeland and housing development, which made prescribed burning more difficult and risky, and likewise, provided a seed bank of competitor species closer to native prairie. Studies have consistently shown that woody species dramatically increase on plots that are unburned, compared to regularly burned areas (Hoch 2000[79]; Knight et al., 1994[80]; Bragg and Hulbert, 1976[81]).

Sericea lespedeza (*Lespedeza cuneata*), a.k.a. Chinese bush clover, is another invasive species in the region. Sericea is beneficial for erosion control, hay production, wildlife cover, and food, and it is able to thrive in damaged areas. Beginning in the 1930s, sericea was planted in areas of Southeast Kansas, primarily on strip-mined land, which is highly susceptible to erosion, and poses difficulties in regenerating cover. Sericea establishes itself very well in such conditions, and although it usually needs more than thirty inches of precipitation annually, it has drought adaptive characteristics (Ohlenbusch and Bidwell 2001[82]). The planting of sericea lespedeza continues throughout several states of the country, but in Kansas it is viewed as invasive and a threat to native species primarily in the Flint Hills. Through time, sericea has spread unfettered into sections of native pastureland and currently threatens not just the ecological integrity of the land, but also the economic livelihood of those living there.

Conclusions

Through the past 200 years, the human-ecosystem dialogue in the tallgrass prairie of the Flint Hills has been a continuous, iterative process of the mutual shaping of both the societies that have inhabited the region, as well as the ecosystem itself. American Indians managed both the grasses and the bison through their burning and hunting practices, which contributed to the perpetuation of the tallgrasses by preventing succession to woody species and encouraging bison grazing. In turn, the tallgrasses and bison were embedded in the culture and practices of the Kansa Indians. Euro-American arrival and expansion incorporated the Kansa Indians more deeply into extra-regional trade networks, leading to the eventual over-harvest of bison. Additionally, bison herds declined from the United States expansionist policy that exposed the buffalo to short-term, extractive profit taking in the harvest and trade of hides. As the ecosystem was altered with the loss of buffalo, so too was society.

The Euro-American settlement period was one of dramatic transition for the social-ecosystem of the region. American Indian influence on the land declined precipitously, as the Euro-American settler population boomed during the late nineteenth century. Dramatic population increase meant many more farms, more cattle, and increased agricultural production. While the Kansa Indians had cropped in the bottomlands, their numbers paled in comparison to settler numbers. Settlers plowed much more bottomland for cropping. Farmers attempted cropping in the uplands, but found it exceedingly difficult to subsist as an upland farmer. In a sense, the upland

tallgrass ecosystem resisted human attempts to shape it in the image of eastern croplands. This resistance essentially forced a reorganization of the spatial patterns of social development inherent in the Homestead Act. That reorganization toward larger farm and ranch sizes included, most saliently, the development of a ranching system in which cattle – as many as 700,000 in 1900 – were fattened on the upland tallgrasses, putting on 200-300 pounds in a season.

Trends in the patterns of human use and organization of land holdings were enabled and advanced by the social organization, institutions, and policies of the US government. The Homestead, the Pacific Railroad, and other acts were essentially a blueprint to guide westward expansion, and were of course informed by the worldview, experiences, values, and economic culture of the dominant group in United States society at the time – primarily white Anglo-Saxon Protestants. It was assumed this blueprint could be superimposed on any lands encountered in the newly acquired West. It was further assumed that where biophysical systems did not cooperate, any obstacles could be overcome through new technologies, tools, and techniques, depending on the requirements of resource extraction. Biophysical limits or setbacks in terms of ecological disturbances would be temporary, as the application of reason, science, and market forces would resolve problems of production and accumulation.

Yet, as ecosystems are also part of the dialogue, they resist their own transformation, to a point. In some cases, for example in grasslands that have been plowed and continuously cropped, the transformation is dramatic. The tallgrasses of the Flint Hills appeared to exhibit remarkable resilience in periods of overgrazing and drought. Especially during the droughts of the 1930s when ranchers moved cattle into the region from drier grasslands and when they were heavily overgrazed as a result, the grasses were able to recuperate even when some thought they had been irreversibly depleted. This resilience also enabled production, employment, and markets, to continue in periods when it was not possible in other areas. The notion of resilience and the restorative ability of the bluestem pastures is thus an important theme in the narrative of the Flint Hills tallgrass prairie.

Changes in the extra-regional context can also drive change in the "local" social-ecosystem. World Wars I and II both drove demand and production in the Flint Hills. Moreover, the emergence of the grain-livestock complex in the post WWII period, in which feedlots and meat packers moved to areas over the high plains aquifer, also increased the competitive pressure on the tallgrass prairie. In an era of irrigated, overproduced, and thus relatively low cost feed grains, and expensive pasture lease costs, grass feeding appears comparatively expensive. Beef cattle are now much younger at slaughter, resulting from efforts to fatten them more quickly. From the dominant economic viewpoint, cattle are a commodity in which one invests capital and does not realize a return on that investment until the commodity is sold. If ranchers can accomplish this in eighteen months rather than two to three years, they can realize their return more quickly. Following this rationale, the sooner cattle can be grain-fed in a feedlot, the more beneficial for the investor. Thus, while grass feeding still plays a role in the beef industry, it is now a more specialized role, in contrast to the traditional, general grass-fattening throughout one or more grazing seasons.

Finally, while it seems clear that the tallgrass prairie exhibits remarkable resilience and recuperative abilities in conditions of drought and over-grazing, it is not yet clear if those same

characteristics will provide defenses to invasive species. In the case of red cedar, fire suppression near urban edges is a social choice related to urban development patterns, profit motives, human understanding of ecosystem processes and aesthetic sensibilities. Whether policy makers will understand and be able to address this issue effectively through urban planning boards and public policy remains to be seen. In the case of sericea lespedeza, researchers, ranchers, landowners and others have now recognized it as a major threat to the tallgrass prairie, and are mobilizing institutional resources to address it. That the approach to sericea is now viewed as one of permanent management rather than eradication is a vivid example of social-ecosystem dialogue.

Additional Information

[1] The Flint Hills do extend into a part of northeastern Oklahoma and are known there as the "Red Hills." Because of data and space limitations, and because the major portion of the Flint Hills is in Kansas, we focus only on the Kansas portion here. The data on precipitation and temperature in this section are drawn in part from http://www.konza.ksu.edu/. These data refer to conditions at Konza Prairie. (back to top)

[2] The data on precipitation and temperature in this section are drawn in part from http://www.konza.ksu.edu/. These data refer to conditions at Konza Prairie. (back to top)

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