CHAPTER 1

INTRODUCTION

1. IMAGES OF THE PLAINS

A review in the *Washington Post* of Michael Cook's *A Brief History of the Human Race*[1] drew my attention to this quotation:

> The basis of farming and hence of the whole historical development of human societies, is grass. … This immediately explains why the tropics have taken a back seat in the course of history (even today underdevelopment has an elective affinity for the tropics). The action is where grass is; and grass despite its tropical origins, is most successful in temperate climates.

Whether correct or not (and some of its contentions seem questionable) Cook's phrase "the action is where grass is" seems a good place to begin this book, an examination of future prospects for one of the world's most extensive and extensively developed grasslands—the Great Plains of North America.

Yet another quotation describes the ambience of the Plains in a telling way. The critic Peter Schjeldahl reviews the work of Agnes Martin,[2] a nonagenarian artist whom he describes as "from Saskatchewan, up north on the tabletop of the Great Plains." Her "spare ascetic abstractions," Schjeldahl explains, are influenced by the Plains:

> There is nothing cuddly about nature in that neck of the non-woods, where vicious cold and exhausting heat, ceaseless wind, and, alternating underfoot, snow, ice, sucking mud, and black dust try the soul. By way of compensation there's sky. A tremendous inverted bowl bells down over every horizon—affording far-distant glimpses of other people's weather. The god of the plains is an orthodox minimalist, specializing in brute coups of uninflected space and light. Checkerboard roads and evenly distributed granary towns—mapped

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[1] Norton (2003). Review by Michael Dirda, "Sunday Book Reviews," *Washington Post*, November 2, 2003, p. 15.

[2] Peter Schjeldahl. "Life Work: Two Shows from Agnes Martin," *New Yorker*, June 4, 2004. p. 94.

> in advance, at the time of settlement, by governmental and railroad bureaucrats—advertise humanity as a complementing force of sublime heartless logic. A sense of existence as seamless and intractable—all one hard thing—crushes and exalts the plains dweller, inducing both humility and lofty thoughts.

However that may be, the grass cover and the landscape of the Great Plains have surely influenced its peoples and their way of life.

2. GRASSLANDS

Grasses give the Great Plains its character. Prior to European settlement the bulk of the biomass in the native vegetation of the Plains was composed of grasses in which other herbs and shrubs grew. Most grasses in the Great Plains are perennials. Vinton (2004) describes their species distribution as follows: Tall grasses grew in the eastern more moist portions of the Plains. The dominant species were big bluestem (*Andropogan gerardii)*, switchgrass (*Panicum virgatum*) and Indian grass (*Sorghastrum notans*). Short grass prairie typified the western regions where rainfall is more limited. The dominant grasses were blue grama (*Bouteloua gracilus*) and buffalograss (*Buchloe dactyloides*). Mixed grass prairie lay between the tall and shortgrass prairies. Grasses typical of both bordering regions appear in the mixed prairie as well as such species as little bluestem (*Schizachyrium scoparius*) and western wheatgrass (*Agropyron smithii*). The northern portions of the mixed grass and tallgrass prairies extend into Canada and include more of the cool-season species. There is also an area in the Canadian Prairie Provinces dominated by rough fescue (*Festuca scabrella*). The southern portion of the mixed grass prairie is dominated by the warm-season grasses—little bluestem and side-oats grama (*Boutelova curtipendula*).

As Vinton explains, the dense fibrous root system of these grasses and the annual dieback of the aboveground portions of the grasses constantly enrich the soil with organic matter, adding nutrients and increasing its water holding capacity. Additionally, grasses persist under drought, grazing and fire. Because of regenerating underground organs that live over from season to season and because of large quantities of nutrients and energy-containing compounds stored in the root system, grasses can recover when their aboveground portions are killed or removed by grazing. The soils that developed under this vegetation are the foundation of Great Plains agriculture. Grazing on the untilled land has changed both the mix of species on the range and its productivity.

3. "DISCOVERING" THE PLAINS

3.1. Pre-European

If it can be said that the Great Plains was "discovered" it was, of course, by the ancestors of the people we in the USA now call "Native Americans" or, in Canada, members of the "Original Nations." Their immensely rich history and

accomplishments cannot be done justice in this work since, limited by necessity, this book deals, essentially with land use in the Plains after exploration and settlement by people of European origin. Prior to the early appearance of Europeans on the Plains, Native American tribes had lived mostly along streams in semipermanent settlements. Because they lacked the means of rapid long-distance movement, the Indians were not always able to reach the migrating herds of buffalo which were their primary source of food. That is, until horses, reintroduced to the region by Spanish explorers of the Southern Plains, became available to them in the early 17th century. By the early 19th century, when American settlement of the region was beginning, Indians roamed the region extensively, able to freely follow the buffalo migrations.

3.2. Early explorations

Early European-origin explorers of the region adopted very different views of the Plains. Reports of the Lewis and Clark Expedition (1803–1806) described many areas lacking all timber and a scarcity of water. The far northwestern corner was described as a "desert." Zebulon Pike crossed from the Missouri River to the Rocky Mountains through what is now Kansas in 1805–1806 and in a report to the War Department described that region as a "desert." "These vast plains of the western hemisphere may become in time as celebrated as the sandy deserts of Africa," Pike's report stated.

Stephen Long crossed what is now Nebraska with his expedition of 1819–1820. His reports provided little to contradict Pike's earlier findings. Indeed, a map drawn by the Long Expedition's cartographer labeled the Missouri and Arkansas basins as "Great Desert"—a notion that persisted through much of the 19th century. Dick (1975) reports on accounts by succeeding travelers—virtually all of which (despite much evidence to the contrary) reinforced the notion of the Great Plains as a desert.

The Canadian portion of the Plains also received "unfavorable reviews" from its early and influential surveyors, John Palliser and Henry Hind (1857–1860). Palliser described the region as "…sterile with scanty pasturage"—an extension in a sense of the "Great American Desert."

3.3. Settlement

Despite these reports, by the 1850s settlements were beginning to appear in Nebraska on the western side of the Missouri River and at the eastern edges in what are now the eastern Great Plains states. Little by little the "border" of the desert pushed westward.

Encouraged by the Homestead Act of 1862 which offered free land to early settlers and by the railroads which had received extensive land grants along their rights-of-way, the farming frontier moved westward more rapidly. Reports of excellent crops on the newly broken prairies further weakened belief in the

existence of a Great American Desert. The Homestead Act provided settlers with 160 acres of land and a mule. Settlers were required to live on the land for 5 years and improve it before they could gain title. At least some portion of their homestead was to be cultivated. In the humid eastern regions of the country the acreage provided was more or less sufficient. In the semiarid west, however, 160 acres (~65 ha) proved too little to support a family.

The 1870s were a period of higher than normal rainfall. Boosters urged more settlers to move into the region. Even the scientific establishment of the time speculated that settlement had changed the climate for the better. One theory cited by Dick (1975) proposed that settlement would reduce the numbers of prairie fires and as a result more trees would grow which would in turn increase rainfall. Another theory proposed by Professors Charles D. Wilber and Samuel Aughey of the University of Nebraska was summed up in the expression "rainfall follows the plow." As Aughey explained: "It is the great increase in the absorptive power of the soil, wrought by cultivation, that has caused, and continues to cause an increasing rainfall in the State." According to this theory, the surface of unplowed prairie soil is compact from the treading of countless buffalo and other animals and absorbs little of the falling rain; most runs off to the nearest streams. By contrast, plowed soil, like a sponge, is open to absorbing all of the rain that falls and, through evaporation, slowly releases that moisture back into the atmosphere where it makes rain. This theory, put forth by my distinguished predecessors at the University of Nebraska, was quite misinformed. Careful observations show that where soil is vegetated its permeability remains high. The aggregated crumbs of newly tilled soil, if uncovered for long, are quickly broken down by heavy rains and the surface is compacted and/or crusted-over. Bare soil in such condition is eroded as water runs off the land.

The notion that "rainfall follows the plow" gave boosters a strong argument to encourage settlement and further westward advance of the farming frontier. The generally good rains of the 1870s and 1880s encouraged a great rush across the 100th meridian with some counties populated in a year or two. Ranchers, however, continued to argue that only grazing was sustainable (not then a "buzzword") in the western reaches of the Plains.

A more valid "scientific" assessment of prospects for the Plains region was that of John Wesley Powell in his *Report on the Lands of the Arid Region of the United States* published in 1879. In a sense his findings favored the western rancher's view by recommending that west of the 20 inch (~500 mm) rainfall belt—roughly the 100th meridian—land should be used only for grazing, irrigated farming, or semiarid cropping.

In the late 1880s and almost continuously in the 1890s nature, unconvinced that "rainfall follows the plow," returned to more typical patterns and then to a severe and protracted drought. Settlers were forced to move back to eastern portions of the Great Plains states and even further east. Historian Henry Nash Smith (1950) described the settlement patterns on the Plains between 1870 and 1890 in this way: "settlement advanced far out upon the Plains in periods of relatively high rainfall, only to be forced back by the dry periods which always

followed." Dick (1975) also writes of "…a surge of settlement cut short in 1874 by grasshoppers and drought."

The Canadian portion of the Plains was settled in a somewhat more deliberate manner than the American portion. Prior to 1869, when it was sold to the new Dominion of Canada, the region belonged to the Hudson's Bay Company. The government's objectives were to people the Prairie Provinces with farm families, to connect the region to central Canada with a railroad and to exploit the region's resources (Thompson, 2004). The Dominion Lands Act of 1872 was modeled after the US Homestead Act, requiring that farmers plant their 160 acres, build a home (even if only a shack) and survive on the homestead for 3 years. As in the USA, private railroads were subsidized by government and granted large areas of land. The path of the railways influenced settlement patterns in Canada as it did in the States. European settlement of the Canadian Plains began in earnest, however, only in the first decades of the 20th century.

The US Congress attempted to remedy deficiencies in the 1862 Homestead Act with regard to the western Plains. The Timber Culture Act of 1873 aimed, because of their supposed benefits, to promote tree-planting in the treeless areas of the West. It allowed settlers to expand their holdings if they planted and maintained trees for a certain period.[3] The program proved ineffective and the law was repealed in 1891.

Next came the Kinkaid Act of 1904. This was at first a special homestead law which applied only to the western and central portions of Nebraska (primarily the Sand Hills). The act allowed for larger homesteads in the designated areas, except for lands set aside as being suitable for irrigation. The act was an effort to respond to the fact that 160-acre tracts were far too small for productive agriculture and ranching in the relatively arid Sand Hills and high plains regions of Nebraska. The Kinkaid Act allowed acquisition of one section (1 sq. mile: 2.6 sq. km), equal to 640 acres (~260 ha).

The settlement policies of Canada and the USA differed in one important way. Canada allowed certain groups like the Mennonites to live in "hamlets," away from their land and yet earn title after farming it for 3 years. Other groups such as Icelanders, Mormons, Jews, Ukrainians, and Hutterites were drawn to the Prairie Provinces. Prosperity based on good crops prompted continued immigration from Eastern Canada, Europe, and the USA in the early decades of the 20th century.

4. THE DUST BOWL YEARS

The cycle of settlement in and after good years followed by out-migration during and after bad years continued, with most severe consequences when drought inevitably returned to the Great Plains in the 1930s.

The terms "Dust Bowl" and "Dust Bowl era" are properly applied to the southern Plains region covering southwest Kansas, eastern Colorado, northern

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[3] Nebraska State Historical Society, US Government Land Laws in Nebraska, 1854–1904. (http://www.nebraskahistory.org/lib-arch/services/refrence/la_pubs/landlaw7.htm)

New Mexico, and the Texas and Oklahoma Panhandles. The term "Dust Bowl" is, however, often associated in the popular mind with the entirety of the Plains region. Overcultivation and overgrazing, especially in the southern Plains had exposed soil surfaces, making them susceptible to wind erosion under conditions of drought. The rapid expansion of wheat production during and after World War I contributed to the increased vulnerability of the region to dust storms. Hurt (2004) describes how the Dust Bowl began with drought in fall of 1931 ruining the wheat crop so that by late January of 1931 the prevailing winds began to lift the soil setting off dust storms.

The dust storms and the concurrent economic depression that began in October 1929 created conditions that required federal government response. Programs were developed to provide funds to farmers agreeing to limit wheat and cotton production as well as price supporting loans for these crops. The Soil Conservation Service encouraged adoption of erosion reducing techniques such as contour terracing, grass water ways, strip cropping and others, and provided financial assistance to enable farmers to make the necessary changes. Wind-eroded land was purchased by the government and returned to grass cover; these areas are now known as National Grasslands. These and a host of other governmental interventions played a very important role in stabilizing Plains agriculture and providing a "safety net" for its farmers. As Wilhite et al. (1986) have shown, these and follow-on programs have considerably moderated both the physical and societal impacts of subsequent droughts on the Plains.

It is also apparent that government resettlement policies were influential in encouraging out-migration from the southern Plains Dust Bowl. But according to Bonnifield (1979) many more people "toughed-it-out" than actually abandoned the region. This he attributes to the fact that the original settlement process was a difficult one and hardened the populace. And the experience of good years and bad had also imbued in them a realistic expectation of what life in the region had to offer. It was the coupling of the two drivers—drought and economic depression—that explains the extensive out-migration from the Great Plains during the 1930s.

Lessons of great consequence for the region were learned during the Dust Bowl years. The severity of the drought in the early 1930s prompted a strong and, on balance, effective response from the US Federal Government. Some programs were already in effect by 1936 when the *Report of the Great Plains Drought Area Committee* was submitted to President Franklin D. Roosevelt (Cooke et al. 1936).[4] The aim of this high-level committee was to "outline a long term program which would render future droughts less disastrous" and to assure the "most efficient utilization of the natural resources of the Great Plains area." By the time of report issuance the federal government had already expended some $475 million on drought related conservation works as well as grants, loans, and

[4] These programs included the Resettlement Administration, Civilian Conservation Corps, Works Progress Administration, Agriculture Adjustment Administration, Soil Conservation Service and Rural Electrification Administration.

relief disbursements. And, as earlier commentators had found, the Committee attributed the distress of the region to overcropping, overgrazing, and the "improper" farm methods being employed. A fundamental cause of the problem, it asserted, was the removal of the region's original grass cover, leading to soil erosion. More specifically the report attributed the heightened vulnerability of the region to drought to a "mistaken homesteading policy and the stimulation of wartime demands." In essence increased cultivation of the region (from l2 million acres in 1879 to over 100 million acres in 1929) enabled by increasingly powerful farm machinery facilitated removal of the grass cover and overgrazing had weakened the remaining cover.

The Committee concluded that, since any permanent increase in rainfall in the region is inconceivable and methods of farming employed by many were better suited to the humid east than to the semiarid Great Plains, farming must be altered to conform to natural conditions. And it further concluded that the farmers of the region were helpless at that stage of the drought and depression to control events; thus a concerted coordinated effort of local, State, and Federal agencies was required to stabilize the region's economy, provide a better, more secure income for each family and spread the shock of inevitable future droughts.

Just as the Roosevelt administration developed agencies and programs to provide assistance and stability to the US Great Plains so did the Canadian government. The Prairie Farm Rehabilitation Administration (PFRA) was established in 1935 in response to the drought and soil erosion occurring in the Prairie Provinces at the time. That agency continues to provide a wide range of financial and educational services to farmers of the region.

5. POST DUST BOWL TRENDS

The long drought ended in the Great Plains and surrounding regions around 1940 as the nation was beginning to emerge from depression—a bit earlier in the Arkansas and the Texas Gulf than in the Missouri Basin (see Figure 2-4). Even before US entry into World War II (December 1941), the war had increased demand for export of agricultural products produced on the Plains. Demand continued to be high in the first postwar years.

Due to the efforts of state and federal researchers yields of the major agricultural crops, including those grown on the Plains, had risen, albeit slowly from the early 1900s to the early 1950s. Thereafter research and development in both the governmental and private sectors contributed to further but more consistent and rapid increases in crop yields. A number of factors have contributed to this phenomenon. Advances in plant breeding permitted the development of crop varieties with increased resistance to disease and insect attack and to greater plant tolerance of temperature and moisture stress. Advances in farm mechanization and the use of chemical fertilizers and pesticides also contributed to rising yields and productivity.

US corn statistics illustrate this phenomenon. About 44 million hectares (109 million acres) of corn were planted in the USA in 1931. Area planted

to corn had decreased to 33 million hectares (81.6 million acres) by 2005. Yet from 1931 to 2005 production rose from 56 to 280 million metric tonnes. Yields rose more than sixfold from 1.54 to 9.31 tonne ha^{-1}. Real prices to farmers have been flat or declined over this period.[5] This trend of increasing US corn yields over time is discussed in greater detail in Chapters 4 and 6.

Another major trend has been the growth of irrigation. In 2002 there were about 22.3 million hectares (55 million acres) irrigated in the USA. In 1974 the area irrigated had been 17 million hectares (42 million acres). Since the early 1960s area of irrigated land increased significantly of the Great Plains, most rapidly in the portions overlying the High Plains aquifer (described in Chapter 2). By 1998 Nebraska was second only to California with about 2.4 million hectares (~6 million acres) in area irrigated. The Texas Panhandle and southwestern Kansas had also become major centers for irrigation.

Government support of agriculture did not end with the 1930s drought, as some of its advocates assumed that it would after that crisis had passed. The US Great Plains region continues to get its share—actually more than its share—of dollars under a wide range of federal agricultural support programs.

As is true throughout the USA and Canada, rural population in the Great Plains has declined substantially as a percentage of the total population although in total number that population is more or less stable in the US Plains. And as is also true of both nations, the median age of the rural population and particularly that of farmers has increased from the Dust Bowl days to today. Another noteworthy, if disturbing, fact is that rural counties in the US portion of the Plains are among the poorest in the nation.

It is important in setting the scene to note that the facts and trends enumerated above encapsulate the current condition of the Plains region: aging population, increased production capacity, continued but lessening overtaxing of soil and water resources, fluctuating but often low commodity prices, generally low rural incomes, continuing dependency on governmental support and continuing vulnerability to drought and other climatic stressors. These facts and trends are dealt with in greater detail in the chapters that follow.

6. THE CHAPTERS

As a basis for understanding the region's current problems and future potential Chapter 2 provides a description of the physical environment of the Great Plains region, its boundaries, climate, soils, water resources, original vegetation, and current land use and identifies other regions of the world that are similar in soils, climate, and agricultural potential.

The demographic makeup of the region, its overall economy, and especially its agricultural economy, are described in Chapter 3.

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[5] National Corn Growers Association. http://www.NCGA.corn/Ethanol/pdfs/2006/Howmuchethanolcan%20comefromcom.v.2.

Chapter 4 has two main aims: (1) to provide a detailed survey of the current geographical distribution of dryland and irrigated crops and animal production on the Plains; and (2) to examine whether or not current uses of the land are "sustainable." Soil erosion and overexploitation of the region's water resources appear to be the most serious threats to sustainability. Therefore, this chapter provides a detailed examination of the current severity of these threats and measures for their control. The concept of a "Buffalo Commons," proposed as an alternative to current use of the Plains region, is examined closely.

Chapter 5 is titled "The Wildcard of Climate Change." Hard as it is to contend with its difficult and highly variable current climate—the factor that most severely limits the long-term productivity and stability of the Great Plains—the prospect that its climate may change (for better or worse) as the result of global warming requires examination. This chapter provides a "mini-primer" on the science of global warming and an assessment of how the Great Plains in particular may be affected. Adaptations to climate change relevant to the Plains are also considered.

Chapter 6 addresses the two key questions raised in this book: (1) Can further global warming (and by inference the threats it poses to the region of interest) be forestalled, controlled, or reversed? (2) Is there a particular role for the Great Plains in any comprehensive strategy aimed at accomplishing this? To address these questions, a detailed review is presented of the role of technology in reducing demand for fossils fuels and in providing substitute supplies of energy. Soil carbon sequestration and biomass for direct combustion or conversion to liquid fuel are the technologies emphasized in this chapter. The scientific background for these technologies, experimental evidence of their efficacy and modeling studies examining their overall potential are described. A separate section of the chapter deals with genetic engineering as it might be applied to increase yields and improve quality of biomass crops, both woody and herbaceous, and as it might help to improve agricultural yields and maintain the capacity to produce food and fiber on a land area reduced in size by a significant conversion of land to biomass production. Economic factors that might favor or restrain the market penetration of soil carbon sequestration and biomass are also examined.

Finally, Chapter 7 summarizes the findings of previous chapters and, in the rapidly changing world of global change science, politics and economics, presents as up-to-date an assessment, as the publication process will allow, of the prospects that there may indeed be "A Biomass Future" in store for the North American Great Plains (NAGP).

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