CHAPTER 7

OUTLOOK

1. RECAPITULATION

To recapitulate the salient points made in the preceding chapters:

The NAGP, extending from North Texas into the southern portions of the Canadian Prairie Provinces, was a vast grassland before the European settlement. Tall grasses dominated the subhumid eastern region and graded with decreasing annual rainfall through a zone of intermediate grasses in the central portion to short bunch grasses in the drier west. Since settlement, the grasslands of the NAGP region have been largely converted to agriculture and ranching.

The region, covering some 2.25 million square kilometers, is one of abundant natural resources. It is endowed with mostly productive or potentially productive soils. Deep, fertile, mollisols dominate the region. All of the NAGP's soils are subject to wind and water erosion. The water resources of the region are substantial although not uniformly distributed; in some portions they are insufficient to meet all needs. The major river systems of the region flow eastward to the Mississippi and northward to Hudson Bay. The region has one major underground water resource as well—the overused Ogallala or High Plains aquifer. The water resources of the region are threatened by groundwater mining, point and nonpoint source pollution of groundwater and of runoff water to streams. The water resources could be very sensitive to the effects of climatic change.

Climates of the Great Plains range from subhumid in the east to semiarid in the west and from near dry tropical in the south to near Boreal in the north. It is the region's rapidly fluctuating atmospheric conditions (its weather) that most clearly determine the extent to which the region's agricultural and grazing potential is reached in any given year. The stressors of extreme temperatures (both high and low), shortage or overabundance of precipitation, severe and sometimes damaging winds and hail storms directly affect crop and pasture growth. These also determine the nature and severity of pests—insects, diseases, weeds—setting an upper limit on the region's agricultural and grazing potential. The climate has some good features: ample sunshine and generally dry weather at harvest offer some distinct advantages over other agricultural regions.

In spite of its climate (most particularly its frequent and severe droughts) the NAGP is one of the world's prime agricultural regions. Fifty percent of US

Great Plains land is in range, 25% in crops, 15% is in forest, with the remainder in a variety of special uses (Chapter 2). Fifty-five percent of the Canadian Great Plains land is cropped. The region produces 21% of the US corn crop and 9% of Canada's; 52% of the US wheat crop and 89% of Canada's; and 93% of US canola crop and 98% of Canada's. Together the US and Canadian Great Plains supply 8% of the world's corn, 8% of its wheat, and 12% of its canola. The region also produces 50% of US cattle and 50% of Canada's; 12% of US hogs and 25% of Canada's; and 37% of US sheep and lambs and 30% of Canada's.

These impressive statistics notwithstanding, all is not well on the Plains. Once thought to be a "Great American Desert," the region seemed to its earliest explorers an unlikely candidate for agrarian settlement. Yet, even before the Civil War, settlers were pushing at its eastern edges. Ever since the process began, the wisdom of breaking the sod and removing the original grass cover to make way for agricultural crops has been vehemently debated. Imperfect adaptation to its natural limitations, inappropriate settlement policies, management failures, and what some consider perverse economic incentives raise questions yet today about the region's long-term sustainability. Since settlement began there has been conflict over the proper land use for the region. Boosters (whatever their motives) encouraged farming on the Plains. Government policies such as the Homestead Act favored it. Still today, government price supports and other forms of payment continue to encourage farming on the Plains.

Surveyors like Powell in 1879, grounded in the science of that time, argued for maintaining grass cover on as much of the land as possible. So, too, did the *Report on the Future of the Great Plains* presented in 1936, during the dust bowl era, to President Franklin D. Roosevelt. Today, the notion of a "Buffalo Commons", a return of much of the western Plains to grass with buffalo herds roaming in it, has its adherents. The sustainable agricultural movement, while somewhat more nuanced in its approach, also strongly favors a return of much of the land to native grasses, or at least better managed grasslands for grazing.

Whatever the merits of these arguments, there are some distressing facts about the Great Plains—at least its still rural portions. The region is poor and highly dependent in the USA upon government payments for survival. The population is declining in many but not all rural counties, and is certainly declining as a proportion of the total population. Although US and Canadian government programs since the 1930s have provided significant help, the region remains extremely vulnerable to the effects of drought, whether protracted as in the 1950s or short and intense as in 1976–1977. As this is written (August 2006) much of the US portion of the Plains (all of Montana, Wyoming, and the western halves of North Dakota, South Dakota, and Nebraska) was again experiencing severe drought. Portions of the Prairie Provinces were also experiencing significant shortages of rainfall at that time, especially southeastern Manitoba.

Against this backdrop comes an additional complication—the prospect of climatic change. Virtually all scientists who have studied the matter are convinced that the continuing emissions of greenhouse gases into the earth's atmosphere will lead to global warming and a consequent change in climate worldwide. Indeed the evidence strongly suggests that the warming is already occurring. Although the timing and geographic distribution of "greenhouse-forced" climatic change are still quite uncertain, it seems more probable than not that temperatures will rise in the Great Plains region—probably more so in the north than in the south. The amounts, intensity and timing of precipitation are also likely to change. Because so much of the region is "on-the-edge" in terms of extreme temperatures and marginal precipitation, it seems likely that the effects of climate change will be significant and more profound than it might be in other adjacent and more amply watered or more temperate climatic zones such as the Cornbelt. It is important to reemphasize here that while how, specifically, the Plains region will be affected by climatic change is uncertain, global warming-forced climatic change, *per se,* is virtually certain in the region's future.

Simple enough to say that since crops respond to temperature their yields will be affected by climate change. Simulation studies using the most credible of the general circulation model projections of future climatic changes suggest reduced productivity for the Plains. But rising temperatures can bring positive changes such as longer growing seasons for annual crops in cool, high latitude zones. The most credible projections suggest reductions in precipitation. Changes in precipitation regime will directly affect crop and rangeland productivity as well as water supplies for irrigation, navigation, recreation, municipal and industrial uses. Certain of the direct effects of changing temperature, precipitation, humidity, etc. could be offset to a degree by the rising atmospheric concentration of CO_2 which tends to stimulate photosynthesis while reducing plant water consumption (transpiration). But, as explained in the foregoing chapters, there are no sure bets in the lottery of climate change, and while potentially positive impacts are possible, greater rather than lesser climatic stresses are more likely in the future. It would be unwise for farmers and policymakers anywhere to bank on potentially positive climatic changes.

The aforementioned impacts (which do not consider farmer adaptations) could be quite serious. However, there is some reason to believe that, given the necessary budgetary support and absent extreme changes in climatic conditions, agricultural science, which has demonstrated remarkable adaptability and versatility in the face of drought and other stressors (recall Figures 6-7 to 6-9) will provide tools needed to keep losses to a minimum. Logically, the science establishment should already be at work developing adaptations to climatic change by, for example, breeding cultivars with greater tolerance to drought and high temperatures. Adaptations of this kind make sense as "no-regret" strategies. Even if climate change fails to materialize, they are needed to better cope with the current climate of the Great Plains and of similar regions. But adaptation can carry us just so far. It is no less important that a serious strategy for the mitigation of greenhouse warming be developed and implemented. This is a job for all governments and all peoples, Plainsmen and women included. And of primary importance if greenhouse warming is to be moderated or avoided is the reduction in greenhouse gas emissions, primarily through reduced consumption of fossil fuels.

2. BIOMASS AND THE GREAT PLAINS

The NAGP is not the only agricultural region that can contribute to the goal of mitigating climate change, but it can contribute importantly and may have more to gain in both absolute and relative terms than other regions. One opportunity is through restoration of carbon to its soils which, by increasing soil fertility and moisture-holding capacity and protecting against wind and water erosion, has the potential of improving and stabilizing crop yields in the region. Another opportunity is through the production of biomass which can be used to reduce the need for fossil fuels and provide important new economic opportunities for the region's farmers and for agricultural industry.

The first of these climate change mitigation methods—restoration of soil carbon offers a relatively simple and inexpensive way of combating climate change. As explained in foregoing chapters, the soils of the Plains lost a large portion of their carbon-containing organic matter when they were converted from grassland to farming. The carbon in that organic matter was oxidized to form CO_2 which diffused into the atmosphere. Some of the lost carbon can be returned to the soil and sequestered there. Additionally, the farm management practices that foster soil carbon sequestration, such as minimum and zero tillage, reduce the energy requirements in agriculture and are environmentally benign in other ways.

The second of the mitigation methods—production of biomass for direct firing and to produce transportation fuels—offers a practical way to significantly reduce both the need for fossil fuels and CO_2 emissions to the atmosphere. The opportunities that biomass provides and the problems it raises are the major focus of this book. Although they have been discussed in considerable detail in the foregoing pages, a few key issues with regard to biomass production on the Plains should be reemphasized here.

A substantial research effort has identified switchgrass as well suited for biomass production in the US Midwest and South and in eastern Canada. Its suitability for the eastern Plains has also been demonstrated. Because of its warm season metabolism and deep and extensive root system, this species is better suited than the traditional crops grown on the Plains to the high temperatures and moisture stress of projected climatic change for the region. Of course, corn and soybeans, the crops that are currently most important in production of ethanol and biodiesel, also grow well in the eastern Plains. And the ample supplies of corn stover and other crop residues to be found there can be used as feedstock for cellulosic ethanol production.

Less effort has been devoted to identification and management of plant species that can produce biomass reliably in the drier western portions of the Plains, although research is now intensifying there. It is the agriculture of this drier region whose ecological and economic sustainability is most precarious. Biomass production may offer an opportunity to effect land use changes that foster sustainability in that portion of the Plains and provide new economic opportunities for its farmers and wider employment opportunities for its citizens.

Legitimate concern has been raised about whether conversion of large areas of US and Canadian crop producing land to biomass production will diminish food and feed supplies and lead to shortages and price increases that ultimately upset domestic consumers and international markets. Some of this concern can be allayed by the recognition of the fact that as the result of a steady stream of improved varieties, fertilization, and other management practices, crop and forage yields continue to increase steadily in the USA and Canada, as they have since the mid-20th century. Traditional plant breeding augmented by genetic engineering should help continue, if not accelerate, this trend and, in so doing, help offset some of the effects of land conversion from food and feed crops to biomass. Genetic engineering can also contribute to improvement in quality of food and biomass crops; in the latter case by, for example, increasing cellulose content to enhance ethanol yields and/or by suppressing flowering to reduce the risks of undesirable gene transfer to other related plant species.

Converting large portions of the Plains to production of biomass crops will not satisfy the ideal of a return to pristine grassland or even, for that matter, to a tourist-attracting “Buffalo Commons”. But since perennial grasses provide the soil cover that protects against wind and water erosion, provides habitat for wildlife and could provide emergency forage in times of drought, it would surely be a move in an ecologically sound direction. Once established, perennial grasses are environmentally benign in that they require less fertilizer and chemical pest control than do the annual food and feed crops they would replace. And after stand establishment the grasses require no tillage for 8 or 10 years until the biomass crop is rotated into other crops or a new stand of grasses is planted.

3. IS THERE A BIOMASS FUTURE?

In view of all of the foregoing information, what are the general prospects for a biomass-based industry? Four trends converging at this time appear to favor its prospects. These can be described under four headings: environmentalism, “petropolitics”, rising energy prices, and achievements in biomass-related research.

Environmentalism: The first trend to note is growing public concern for “the environment” which manifests itself in many ways. Most relevant here is what this book calls “The Wildcard of Climate Change”. We are virtually certain that the world will continue to warm with continuing emissions of greenhouse gases into the atmosphere and that climate will change throughout the world although we are much less certain about how and where these changes will be manifested. Despite the remaining uncertainties, public concern about global warming has been rising steadily in the USA, Canada, the European Union, and elsewhere.

The need to reduce CO_2 emissions is understood by the public generally, not only by climate change specialists and environmentalists. Since the combustion of coal, oil, and natural gas is the principal source of the CO_2 emissions, demand is growing for technologies that enable renewable energy resources to be used as substitutes for these fuels. That biomass appears to be among the least environmentally risky alternatives for reducing current use of fossil fuels increases public interest and support for it.

One of the important obstacles to wider acceptance of biomass has been the concern that the net energy balance (NEB) of its most prominent product thus far, ethanol from corn, is modest and that its price has been artificially lowered by various forms of government support. Recent research indicates that the NEB of corn-based ethanol—about 25%—is modest, but that of biodiesel from soybeans is more than 90%.The NEB of cellulosic ethanol is expected to be better than that of ethanol from corn.

The surging interest in prospects for biomass for ethanol and other purposes is evidenced in the media. In an article entitled "The Race Against Climate Change", in the *Business Week* of December 12, 2005 reports that leaders of greenhouse gas emitting industries, anticipating mandatory limits on emissions, are already moving to measure and slash their greenhouse gas emissions: "One new twist in the discussion of global warming is the arrival of a corps of sharp-penciled financiers. Bankers, insurers and institutional investors have begun to tally the trillions of dollars in financial risks that climate change poses." Major corporations have announced plans to develop activities contributing to the mitigation of climate change. General Electric, for example, has promised to double its investments in environmental research and to lower its emissions modestly.[1] Another good example of this trend is the environmental policy announced in 2006 by the investment banking firm Goldman Sachs. That policy states: ". . . we will work to ensure that our people, capital and ideas are used to help find effective market-based solutions to address climate change and other critical environmental issues, and we will seek to create new business opportunities that benefit the environment."[2]

Further evidence of the growing power of public concern with climate change, if such is needed, appears in US President George W. Bush's call in his 2006 "State of the Union" address to Congress[3] for research and development leading to methods of producing ethanol from crop and woody waste materials (cellulosic ethanol, in other words). "Our goal is to make this new kind of ethanol practical and competitive within six years", he stated. This from the

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[1] http://www.businessweek.com/magazine/content/05_50/63963401.htm Find G.E. announcement on the web

[2] http://www2.goldmansachs.com/our_firm/our_culture/corporate_citizenship/environmental_policy_framework/index.html

[3] http://www.cnn.com/2006/POLITICS/01/31/sotu.transcript/

head of an administration apparently unconvinced of the reality and/or potentially serious consequences of global warming and staunchly opposed to the imposition of any but voluntary greenhouse gas emissions controls!

Petro-politics: The second trend is geopolitical in nature. Nations whose economies depend on imported petroleum have come to appreciate their sensitivity to global "petro-politics" and vulnerability to the consequences should global terrorism be focused on petroleum exporting countries. As so large a share of the world petroleum market is supplied by nations that are currently either hostile to USA or western interests (e.g., Iran, Venezuela) or vulnerable to takeover by groups hostile to the west (e.g., Saudi Arabia, Iraq, the Gulf States, Chad, Nigeria, Libya), the world has become increasingly vulnerable to "petro-blackmail". For decades lip service has been paid by politicians in energy importing nations to the notion of "energy independence." Global political instability of recent years has made energy independence a much more urgent matter than it has been heretofore in the importing countries. Biomass-based transportation fuels can contribute to that goal and reduce our reliance on petroleum and the volatile and potentially unstable petroleum-exporting nations. Brazil, which is now virtually independent of foreign oil imports because of its national ethanol production capacity has become a model that other countries would like to copy. Over 18.2 billion liters (4.8 billion US gallons) of ethanol were produced from sugarcane in Brazil in 2005. Of this, more than 2.27 billion liters (0.6 billion gallons) were exported.[4]

Energy prices: Another trend or factor not entirely dissociated from petro-politics that has raised interest in biomass in public, policymaker, industrial and entrepreneurial circles is the sharp rise in the market price of energy of all forms during the middle years of this decade. This rise can be attributed in part to political instability in some of the petroleum exporting countries. It can also be attributed, simply enough, to demand outpacing supply, a situation prompted by increasing global population and improving standards of living. A major factor in increasing demand and competition for energy sources has been the rapid development and emerging economic power of China and India and to a lesser extent of other rapidly developing nations. Notable, if temporary, decreases in petroleum production and processing caused by natural disasters such as Hurricane Katrina striking the US Gulf Coast in September 2005 and by engineering failures such as the leakage from British Petroleum's Alaskan pipelines in August 2006 have also contributed to the sharp spikes in petroleum prices. In the of summer of 2006 these factors, together, drove the price of regular grade gasoline to over \$3.00 per gallon (\$0.79 per liter) in the USA (with still higher prices elsewhere). This price is well above the \$1.65–1.80 per gallon range, which only a few years ago economists speculated would be required to make biomass ethanol competitive with gasoline.

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[4] http://www.card.iastate.edu/iowa_ag_review/spring_06/article3.aspx

Achievements in biomass research: The practicality of producing biomass crops in the southern and Midwestern US has been demonstrated in long-term research efforts supported by the USDOE and USDA. Field tests of existing and improved cultivars of poplar, switchgrass, and other candidate biomass crops have demonstrated the feasibility of producing them under optimized and sustainable management. The poplar genome has now been successfully mapped (Tuskan et al. 2006) and together with that of switchgrass, when complete, will afford opportunities to genetically engineer these species (and likely others in the future) to increase their productivity, harvestability, and processing characteristics.

The energy in cellulose is locked away in sugars that resist biological and chemical degradation, so that cellulosic ethanol is more difficult to produce than ethanol from grain. Research will be required on enzymatic mechanisms for breakdown of the cellulosic biomass and on processes that reduce cost and overall production. New enzymes (some of them genetically engineered) are being developed in the laboratory and subjected to testing in pilot-scale "biorefineries". The DOE's July 2006 report "Breaking the Biological Barriers to Cellulosic Ethanol" states that recent breakthroughs in biotechnology make possible the release of energy in the sugars that constitute cellulosic materials.[5] It asserts that the replacement of 30% of US gasoline use with biofuels by 2030 is an "attainable goal". Cellulosic ethanol appears to offer the best opportunity for a major increase in the role of renewable fuels. In the long term the contribution that biomass makes to energy independence and greenhouse gas abatement in North America will depend on technological advances and economics circumstances that allow cellulosic biomass to gain a significant market share.

4. CONCLUDING THOUGHTS

The factors discussed above—environmentalism, petro-politics, the demand for energy independence, high energy prices, the putative greening of big industry, and the interest of financial markets—have given biomass a big push forward during the past few years. Biomass seems to have a global future and seems promising for already important food-producing portions of North America. And that form of "biomass" that is soil carbon sequestration is achievable and beneficial virtually anywhere that crops are grown.

Introducing dedicated biomass crops into the regular crop rotation can offer ecological and agronomic advantages in all agricultural regions. With power plants and biorefineries located accessibly, biomass can offer farmers a steadier cash flow than other, more traditional crops, especially if (when?) price supports are withdrawn from the latter. This view of the future applies as well to

[5] Breaking the biological barriers to cellulosic ethanol: a joint research agenda. A research roadmap resulting from the Biomass to Biofuels Workshop. December 7–9, 2005. Rockville, MD. DOE/SC 0095. Released June, 2006.

the eastern Plains as it does to the Cornbelt or the South. In the case of the drier portions of the Great Plains where biomass crops will likely yield less, and transportation costs to power plants and biorefineries could be greater, prospects for a biomass economy are less clear.

A strong argument for biomass cropping in the western Plains is ecological. It is well understood that the region would benefit from an increase in its land area under grass cover. That cover need not be total or permanent but can be included in long-term rotations including wheat, barley, rye, oats, other small grains, or canola. Straw from these crops can also be harvested for biomass purposes. Additionally, the US portion of the Plains has a large proportion of its land enrolled in the Conservation Reserve Program and, as explained in Chapter 6, the vegetation on enrolled lands can be harvested when needed for biomass with little loss of the protection afforded against soil erosion. Although not much research on this matter has been reported, it seems logical that fenced-off areas of range can also be rotated out of grazing and its vegetation allowed to grow until enough accumulates for periodic harvests of biomass.

The extensive irrigation infrastructure that now exists on the Great Plains is used primarily to grow corn and sorghum for grain, for cotton and, to a lesser degree, for wheat, alfalfa, and some specialty crops such as dry beans, sugar beets and potatoes. Concern for the sustainability of agriculture and water security in the region challenges the practice of mining water from underground aquifers in order to irrigate low-value crops like corn and sorghum. This concern is especially strong for aquifers that recharge only slowly, if at all. The current trend toward a reduction of irrigated area in the Plains states that would help to conserve its water resource may, perversely, be reversed by increased demand for grains to make ethanol. An alternative use of the existing irrigation infrastructure could be for limited and infrequent watering of biomass fields to supplement rainfall in seasons and years of shortage. Although not easily done, center-pivot sprinkler systems can be moved from field to field as needed. Other types of sprinkler systems are more easily moved. Biomass crops can also be grown in fields already fitted out for surface irrigation. Agronomic, engineering and economic analyses are needed to establish the practicality (or lack thereof) of these notions on what one might term "Strategic Biomass Irrigation".

In the years before the big run-up in gasoline prices, specialists suggested that transporting biomass for more than 50 miles (80 km) would be too costly. One disadvantage that biomass farming may encounter on the drier western Plains is that, either because of insufficient land committed to biomass production or because of relatively low yields, power plants and biorefineries there will need to draw materials from greater distances. New economic realities could alter the calculus and permit extension of the area from which individual processing plants draw their supplies of biomass. Can we not also envision a situation that justifies the deployment of a denser network of smaller-scale facilities, especially biomass-fired or co-fired electrical power plants that would reduce the need to transport biomass for great distances? Could densification of harvested biomass with machinery that tightly compacts grasses, stover, straw or other waste materials be used to significantly reduce the volume of material to be transported to the processing site? Can biomass headed to the refinery be subjected to partial chemical and/or mechanical processing before it leaves the farm or at local small-scale facilities to reduce the mass of material to be transported?[6] Most intriguing of all these "futuristic" notions is the possibility (discussed in Chapter 6), that the CO_2 released from biomass-burning power plants might be captured at the smokestack and sequestered in geological strata underlying the Plains region. In such a case, biomass would be a means of achieving not only near-zero CO_2 emissions but negative emissions leading to a decrease of the atmospheric concentration of this potent greenhouse gas.

We return, in closing, to the very supportable premise that the Plains region needs more grass in its lands. And its people need greater economic opportunity than the current land-use patterns afford. The construction and operating of biomass-fired power plants and biorefineries and the growing, harvesting, and transportation of biomass to these facilities will provide new employment opportunities to the region.

Of course, the Plains will remain a difficult region to farm. Droughts and other climatic hazards will not cease to stress the region because we will them to. But an agriculture that includes a significant regrassing of the Plains whether prompted by the need for biomass or for other reasons will be a better place for its inhabitants, a contributor to its own well-being as well as to national and global economic and ecological health.

REFERENCES

Tuskan, G., Di Fazio, S., et al: 2006, The genome of the Black Cotton wood, *Populus trichocarpa* (Tonn & Gray). Science 313, 1596–1604.

[6] One intriguing example of this is the suggestion in Shinnar and Citro (cited in Section 6.2.1, Chapter 6) of converting biomass to methanol in small local plants and transporting it to a biorefinery or existing petrochemical plant for further processing.