Executive Summary 1

Bioenergy crops have the potential to improve the environment, increase rural incomes, and reduce Federal budget deficits and the U.S. trade imbalance. In the wake of the devastating Midwest floods, bioenergy crops may also offer a more robust crop for flood-prone regions. To realize this broad potential, continuing research and development and environmental monitoring will be required. It will also be necessary to conduct some long-term and large-scale demonstration programs, and to address a variety of market barriers and distortions. Haphazardly implementing large-scale bioenergy programs without such a foundation could damage the environment and reduce potential economic benefits.

The net environmental impacts depend on what the land was previously used for, the particular energy crop, and how the crop is managed.

BACKGROUND

Bioenergy crops include annual row crops such as corn, herbaceous perennial grasses (herbaceous energy crops—HECs) such as switchgrass, and short-rotation woody crops (SRWCs) such as poplar. Annual row crops are grown in essentially the same manner as their food crop counterparts and consequently offer few or no environmental benefits over conventional agricultural practices. Because of this, annual row crops are not examined further in this report.[1]

HECs are analogous to growing hay, harvesting the crop for energy rather than for forage. SRWCs typically consist of a plantation of closely spaced (2 to 3 meters apart on a grid) trees that are harvested on a cycle of 3 to 10 years. Following harvest,

[1] Energy crops (often annual row crops) exist which produce starches, sugars, oils, and other specialty plant products for energy. On a national basis, however, their energy production potential is much lower and their costs higher than for HECs and SRWCs. Consequently, they are not considered further in this report.

HECs regrow from the remaining stubble and SRWCs regrow from the remaining stumps. Such harvests may continue for 15 to 20 years or more without replanting. Fertilizer and maintenance may be required annually, however. These energy crops may be grown by farmers with only modest changes in farming practices.

A number of factors are considered in selecting specific HECs and SRWCs to be grown. These include their productivity (growth rate); robustness (ability to withstand weather, pests, and disease); efficiency in using water; overall environmental impacts (soil, water, air, habitat, greenhouse gases); and others.

HECs and SRWCs produce very large quantities of biomass—straw, wood, bark, and leaves—composed principally of cellulose and lignin.[2] These feedstocks maybe used to generate electricity or be converted to liquid fuels or combustible gases.

ENVIRONMENTAL IMPACTS

Bioenergy crops can be substituted for conventional crops or be grown on agricultural set-aside or conservation reserve program lands, degraded lands, or elsewhere. The net environmental impacts depend on what the land was previously used for, the particular energy crop, and how the crop is managed. For example, as a substitute for conventional agricultural row crops such as corn or soybeans, properly managed HECs and SRWCs can help stabilize erosive soils or perhaps filter agricultural chemicals and sediments before they reach water supplies.[3] They may help provide habitat directly or serve as buffers around, or corridors between, fragments of natural forest, wetlands, or prairie. (Such habitat benefits will, however, also depend on the particular animal species.) In contrast, substituting energy crops for hay, pasture, or well-managed Conservation Reserve Program Lands generally will have mixed environmental impacts, both positive and negative.

It is important to remember that bioenergy crops are similar to agricultural crops and should not be confused with natural habitats.[4] Current plant species under consideration for use as bioenergy crops are primarily native species that evolved in the regions where they may be used. These crops can provide greater biodiversity on a landscape level than typical agricultural crops, and thus can enhance wildlife habitat. The benefits may be transient, however, depending on the management and harvesting practices required to produce an economically viable crop.

Bioenergy can potentially also improve urban and regional air quality by reducing SO_x and NO_x. If poor-quality equipment or controls are used, however, emissions of particulate and certain organic compounds could be increased by the substitution of bioenergy for conventional fuels.

When grown on a sustainable basis,[5] bioenergy can offset emissions of greenhouse gases from fossil fuels and thus slow potential global warming. In the long-run, if greenhouse gas emissions are not reduced, potential warming may cause the

[2] Cellulose is the fibrous material in plants and lignin is the "glue" that binds the fibers together. Because of this content, these crops are also known as lignocellulosic energy crops.

[3] To serve as a filter and to be harvested periodically for energy, energy crops may require more complex and careful management than is typical for energy crops which do not serve such demanding multiple functions.

[4] Defining "natural habitat" may be difficult and controversial because past decades—sometimes centuries-of clear cutting, selective harvesting of economically valuable trees, and fire suppression have altered many U.S. forests, often leading to an increased concentration of plant species with lower economic or ecological value. Similar alterations have occurred over many other U.S. landscapes, including prairie and wetlands. Although defining how much modification still qualifies as "natural" is thus challenging, the term will be used broadly here to include all lands that support a significant quantity and variety of indigenous plants and animals. For this report, only current or former agricultural lands or highly degraded lands are considered for energy crops.

[5] For example, as much new biomass is grown as is burned for fuel. There are also potential sequestration benefits for both soil carbon and standing biomass.

loss of natural habitats throughout the United States as well as globally.

RURAL ECONOMIC IMPACTS

Rural economies in the United States have been hard pressed for many years. Between about 1980 and 1990, the U.S. share of the world's total agricultural trade dropped from 28 percent to 21 percent. At the same time, the European share grew from about 13 percent to 19 percent. China is now the world's second largest corn exporter, and Brazil is a major exporter of soybeans. Some expect that parts of Eastern Europe and the former Soviet Union could become food exporting powerhouses in the future.[6] Roughly half of the ship-loading grain terminals in the United States are reportedly closed, about to close, or for sale.' Due to these pressures, there is a growing need to find alternative crops for rural agricultural communities: to provide employment, to stabilize rural incomes, and to maintain the rural infrastructure of equipment and supplies distribution and service. Bioenergy crops are one such alternative if mechanisms can be found to overcome a variety of market and institutional obstacles to their use.

FEDERAL BUDGET IMPACTS

The Federal budget is likewise under great pressure and agricultural programs, like everything else, are under increased scrutiny for savings. Currently, Federal programs to prevent soil erosion[8] and various commodity support programs to strengthen crop prices cost roughly $10 billion per year. Bioenergy crops are a potential alternative cash crop that could protect fragile soils or could be grown on lands previously idled in order to strengthen commodity crop prices. Earnings from the energy crop might then allow Federal supports to be eased while maintaining farm income. Of course, the relative environmental benefits of energy crops versus current soil conservation programs such as the Conservation Reserve Program would again depend on the specific energy crops grown and how the land was managed. The relative economic and budgetary value of producing bioenergy crops would have to be compared to potential alternative uses of the land. Designing Federal programs to achieve such ends while minimizing disruption and risk to farmers also presents challenges.

TRADE BALANCE IMPACTS

U.S. expenditures on foreign oil are currently running about $50 billion per year and are destined to increase sharply as domestic oil production continues to decline. Several U.S. electric utilities are also now importing low-sulfur coal. Bioenergy crops could potentially offset some of these imports. Although bioenergy by itself is unlikely to eliminate fuel imports, it could make a substantial contribution to our energy needs.

BASELOAD POWER

In addition to the above potential benefits, biomass energy may play a particularly important role if there is a greater emphasis in the future on using renewable forms of energy. In contrast to intermittent renewable such as solar (available when the sun shines) and wind (available when the wind blows), biomass energy comes as an already stored solar energy resource. It can thus be used as needed rather than as available. Although the intermittency of solar and wind energy can be moderated by gathering them over a large geographic region, they still require dispatchable backup power such as can be provided by biomass.

[6] In the longer term, population growth in developing countries may surpass agricultural productivity growth and increase demand for food imports. Some of this demand may be supplied by the United States. No one knows, however, what the net effect is likely to be.

[7] Scott Kilman, "U.S. Is Steadily Losing Share of World Trade in Grain and Soy beans," *Wall Street Journal, Dec. 3, 1992,* p. A1.

[8] An example is the Conservation Reserve Program (CRP) which pays farmers to take lands out of production of a marketable crop for 10 years in order to protect more erodible or fragile soils with permanent cover.

THE BIOENERGY AGENDA

While bioenergy crops have great potential to help meet a number of pressing problems, the extent to which this potential can be realized will depend on a number of factors. These include:

- Research and development—Relatively little R&D has been done on the environmental impacts of energy crops in the United States. Most studies have been short-term, limited in scope, and confined to small scales. Although careful studies have been conducted at a handful of sites across the United States, the results tend not to be readily transferable to significantly different sites, crops, or management practices. Consequently, most practices in the field, as well as much of the analysis in this report, have been developed by analogy with conventional agricultural or forestry practices. This approach has significant limitations. For example, energy crops can have significantly deeper and heavier rooting patterns than conventional agricultural crops, affecting soil carbon balances, water balances, and agricultural chemical fates. Even less is known about the habitat impacts of energy crops; some of the very first studies are just now underway at a few locations. Virtually all proposed habitat practices are based on ecological theory and by analogy with conventional crops.

  Thus, R&D is needed on soil, water, and air quality issues, and these environmental analyses should be done on a total fuel-cycle basis. R&D is also needed on how to design desirable landscapes at the micro and macro level in order to realize the potential habitat benefits of bioenergy crops, including the relative benefits of buffers and corridors using energy crops—for which almost no R&D has been done to date. Inter-planting multiple species can potentially improve habitat but may complicate energy conversion processes which are typically designed for a narrowly defined input feedstock. Thus, R&D is needed to tailor energy conversion processes to accept a wide variety of mixed feedstocks, particular] y those with special habitat value. Landscape design and conversion processes must also maintain high productivity and reasonable economic returns. Experience gained in Europe and elsewhere in recent years may be useful in addressing these issues.
- Demonstrations-Demonstrations are needed (and should be closely coupled with the above R&D agenda) in order to determine how best to structure energy crops for their environmental (soil, water, air, habitat) value, to determine what their environmental value actually is by field observations, and to establish pilot energy conversion facilities, such as bioenergy to electricity, bioenergy to liquid (transport) fuels such as ethanol or methanol, or bioenergy to other petrochemical substitutes. Such demonstrations are most useful if they are of sufficient scale to clarify the characteristics of a fully functional infrastructure and thus reliably and cost-effectively link the feedstock production activities to the energy conversion processes.
- Commercialization—Farmers cannot afford to grow biomass unless electric power or fuel conversion facilities are in place to purchase it. Conversion facilities cannot be built unless the biomass feedstock is available and an end-use market is ready. An end-use market is difficult to develop without assured supplies of fuel. Infrastructure development may be needed at all these levels. Mechanisms for addressing this "chicken and egg" problem of developing bioenergy production, conversion facilities, and end-use markets are needed. On the biomass production side, this may require addressing issues of farmer risk, flexibility, finances, education and extension, and other issues. Fundamental issues of land use and property rights may also arise in connection with environmental considerations of energy crops. Studies of how best to address these issues might be conducted in parallel with demonstrations.
- **Institutional** Issues—The multiplicity of sectors affected by energy crops—agriculture, energy, environment, forestry, etc.—poses a substantial and, in some ways, unique institu-

tional challenge in developing coherent policy goals, processes, and effective coordination.

Energy crops may help solve some of our national energy and environmental problems. They potentially can provide a modest fraction of our current level of energy needs, perhaps 10 to 30 percent, and they have potential environmental benefits compared with conventional agricultural crops. Energy crops are no substitute, however, for natural habitats on contiguous landscapes; energy cropping should primarily be considered for surplus agricultural and degraded lands. Finally, the regional impacts of energy crops will be mixed. They cannot readily be grown everywhere. They are most likely candidates where agriculture and forestry are already well-established industries.

Within these limits, energy crops show promise to help meet a number of national needs-economic, environmental, budgetary, and national security. The extent to which this potential can be realized will depend on how well the many competing economic/environmental, rural/urban, regional, and other interests can be balanced. This background report is intended to contribute to that national debate.