Ecological Society of America

Policy Statements » Statements: Biofuel Sustainability

Much attention is currently focused on the use of biofuels as an alternative energy source, both to decrease U.S. dependence on foreign oil supplies, and as a means of addressing one facet of global climate change. Supplying the emerging biofuels industry with enough biomass to meet the U.S. biofuel energy target – replacing 30 percent of the current U.S. petroleum consumption with biofuels by 2030 – will have a major impact on the management and sustainability of many U.S. ecosystems. Biofuels have great potential, but the ecological impacts of their development and use must be examined and addressed if they are to become a sustainable energy source.

The sustainability of alternative biofuel production systems must be assessed now, in order to maximize the potential for developing truly sustainable scenarios – that is, profitable systems that can provide adequate biomass with the least amount of environmental damage.

Biomass extraction and the byproducts of biofuel manufacturing will directly affect ecosystems in many ways. Much of the biomass needed for biofuel production will be supplied by croplands. Marginal croplands will be farmed more intensively and previously unfarmed areas will be brought into production. As this happens, the U.S. landscape will change. Current technologies emphasize use of annual and perennial grains. However, crop “leftovers,” such as corn husks and wheat straw, and fiber from perennial crops such as switch grass are likely to contribute as well. The exact mix will depend on a number of factors including emerging technologies, market prices, and policy incentives. That mix will have a major impact on both the long-term sustainability of the biofuel enterprise and on the underlying health of U.S. ecosystems.

The current focus on ethanol from corn illustrates the risks of exploiting a single source of biomass for biofuel production. A growing percentage of the U.S. corn harvest – 18 percent in 2006 – is directed towards grain ethanol production. This has not only resulted in record-high corn prices, it has produced strong incentives for continuously-grown corn, higher-than-optimal use of nitrogen fertilizers, the early return of land in conservation programs to production, and the conversion of marginal lands to high-intensity cropping. All of these changes exacerbate well-known environmental problems associated with intensive agriculture:

- Continuously-grown corn is more susceptible to insect damage and allows weeds to become more persistent, requiring more insecticides and herbicides.
- Nitrogen fertilizer is the principal contributor to nitrogen pollution of groundwater, surface waters, and coastal zones, and a major source of the greenhouse gas nitrous oxide.
- Placing previously fallow land enrolled in conservation programs back into production reduces wildlife diversity, requires irrigation, and releases carbon dioxide.
- Converting marginal lands to agriculture or farming them more intensively creates new sources of agricultural pollution and, in many cases, disproportionately increases nutrient loss and soil erosion; many of these lands are marginal to begin with because they are on sloping, sandy, or wet soils particularly susceptible to soil and nutrient loss.

We must assess the tradeoffs of these impacts with the benefits associated with biofuel development. Current grain-based ethanol production systems damage soil and water resources in the U.S. and are only profitable in the context of tax breaks and tariffs. Future systems based on a combination of cellulosic materials and grain could be equally degrading to the environment, with potentially little carbon savings, unless steps are taken now to ensure that three specific principles of ecological sustainability are incorporated into their design.

1. SYSTEMS THINKING. A systems approach is crucial to assess the energy yield, carbon neutrality, and the full impact of biofuel production on downstream and downwind ecosystems. It should take into account all of the flows, controls, and storage of materials and energy. A positive energy yield means that more energy is produced than is consumed by its extraction and transport. Carbon neutrality means that any fossil fuel carbon used in the production of biofuels is offset by carbon sequestration elsewhere in the system (and the system is the entire globe in this case). A systems approach must consider the effects on interconnected ecosystem processes such as nitrogen emissions from land to air, nitrate and phosphorus export, soil erosion, and other important impacts of agriculture on surrounding landscapes, including pests, nonnative species, and effects on wildlife or protected species. Consistent monitoring of the energy yield, carbon neutrality, and impact on interconnected ecosystems is critical to ensuring the sustainability of biofuel production.

2. CONSERVATION OF ECOSYSTEM SERVICES. A focus on ecosystem services will provide the foundation necessary for win-win scenarios. It is easy to design systems for maximum crop yields; over a century of agronomic research has shown that this can be done very successfully. Managing for other ecosystem services also provided by agricultural landscapes is less common but equally necessary. Lower yields from an unfertilized native prairie, for example, may be acceptable in light of the other benefits provided by native plants in an agricultural landscape. These include:

- A complete and closed cycling of nutrients;
- Minimized flooding and increased groundwater recharge;
- Enhanced carbon sequestration in the soil because tilling would be unnecessary;
- Fewer pests because habitat for insects and birds that prey on them is left intact;
- Genetic diversity;
- Reduced nitrogen and phosphorus runoff because no fertilizer is needed;
- Reduced soil erosion due to continuous soil cover;
- Reduced nitrous oxide production; and
- Pollinator habitat and resources.

These benefits, in turn, would help ensure ecosystem services such as better water and air quality, crop pollination, flood mitigation, runoff reduction, and food and fiber production.

3. SCALE ALIGNMENT. Explicit consideration of scale in policy and management is necessary to achieve sustainability goals. Fields are managed at the level of individual farms, but sustainability must also be assessed at landscape, regional, and global scales. What is sustainable at one scale may be unsustainable at another. Policies must provide incentives for managing land sustainably and encourage the development of alternate technologies to create biofuel from various biomass sources. If used, incentives should be applied to the biomass content rather than the biofuel product in order to spur the development of a diverse portfolio of alternative energy sources.

Finally, biofuel production must also attend to economic impact, particularly on communities least likely to be able to afford higher food prices resulting from demand-driven increases in crop prices.

Taken together, these three principles – systems thinking, conservation of ecosystem services, and scale alignment – can create a sustainable biofuels infrastructure that will serve U.S. citizens, the economy, and the environment.

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The Ecological Society of America is the country's primary professional organization of ecologists, representing 10,000 scientists in the United States and around the world. Since its founding in 1915, ESA has pursued the promotion of the responsible application of ecological principles to the solution of environmental problems through ESA reports, journals, research, and expert testimony to Congress. For more information about the Society and its activities, visit the ESA website at http://www.esa.org.

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