Agriculture in the United States and many other countries is at a critical juncture. Public investments and policy reforms will inform landscape management practices to be used by farmers and ranchers for sustaining food and ecosystem security. Although U.S. farms have provided growing supplies of food and other products, they have also been major contributors to global greenhouse gases, biodiversity loss, natural resource degradation, and public health problems (1). Farm productivity and economic viability are vulnerable to resource scarcities, climate change, and market volatility (2). Concerns about long-term sustainability have promoted interest in new forms of agriculture that (i) enhance the natural-resource base and environment, (ii) make farming financially viable, and (iii) contribute to the well-being of farmers, farm workers, and rural communities, while still (iv) providing abundant, affordable food, feed, fiber, and fuel.

A 2010 report by the U.S. National Research Council (NRC) (1) identified numerous examples of innovative farming systems that contribute to multiple sustainability goals but noted they are not widespread. This report joins others [e.g., (3–6)] critical of aspects of mainstream, conventional farming systems. We argue that the slow expansion of such innovative farming systems in the United States is as much a policy and market problem as a science and technology problem. Incentives for appropriate markets, reform of U.S. farm-related policies, and reorientation of publicly funded agricultural science are needed to hasten implementation of more sustainable agricultural systems.

Incremental, Transformative Approaches

To improve sustainability of U.S. agriculture, the NRC report proposes both incremental and transformative approaches. The former are practices and technologies that address specific production or environmental concerns associated with mainstream, conventional farming systems. Examples include 2-year crop rotations, precision agriculture using geospatial technologies that describe field variation, classically bred or genetically engineered crops, and reduced or no tillage. Although incremental approaches offer improvements and should be continued, in aggregate, they are inadequate to address multiple sustainability concerns.

In contrast, the transformative approach builds on an understanding of agriculture as a complex socioeconomic system. Transformative change looks to whole-system redesign rather than single technological improvements. Examples of such innovative systems make up a modest, but growing, component of U.S. agriculture and include organic farming, alternative livestock production (e.g., grass-fed), mixed-crop and livestock systems, and perennial grains (1). Such systems integrate production, environmental, and socioeconomic objectives; reflect greater awareness of ecosystem services; and capitalize on synergies between complementary farm enterprises, such as between crop and livestock production.

The existence of innovative agricultural systems in the United States suggests that technical obstacles are not the greatest barrier. Rather, change is hindered by market structures, policy incentives, and uneven development and availability of scientific information that guide farmers’ decisions (see the figure).

Policy Incentives

Many international, federal, state, and local agricultural, credit, energy, risk-management, and environmental policies influence farmer decisions (see the Figure). A major policy driver for U.S. agriculture is the Farm Bill, traditionally renewed by the U.S. Congress every 4 to 5 years, with the next version expected in 2012. The best-funded provisions of the Farm Bill include financial assistance for low-income families to purchase food; commodity subsidies paid to farmers (mostly for corn, cotton, rice, soybeans, and wheat); crop insurance and disaster relief; and conservation programs (8). Although only roughly a third of U.S. farmers receive commodity or conservation payments under the Farm Bill, it has a major influence on what, where, and how food is produced.

Most elements of the Farm Bill were not designed to promote sustainability. Subsidies are commonly criticized for distorting market incentives and making our food system overly dependent on a few grain crops mainly used for animal feed and highly processed food, with deleterious effects on the environment and human health (9, 10). Redesigning the bill will be a complex undertaking in light of political and budgetary constraints, as well as knowledge gaps. However, much of the information necessary for Farm Bill redesign is available and
not being used (11). Spending needs to be reduced on programs, such as subsidies, that mask market, social, and environmental risks associated with conventional production systems. Funding needs to be reallocated to encourage markets for sustainability brand products (e.g., by standardizing and defining sustainable product attributes) and to increase support for farming systems that balance all four sustainability goals and are more resilient to resource scarcities and global market variability.

With a new version of the Farm Bill due next year, we think the time to start reform is now. In addition, progress in other policy arenas is needed to address conflicting incentives and unintended consequences. Unless we integrate agricultural sustainability into debates over biofuels and other energy policies, climate change, trade agreements, immigration reform, and environmental regulation, we are unlikely to see major changes in policies that created and continue current production systems.

**Agricultural Science and Knowledge**

The publicly funded agricultural science portfolio could be reoriented toward agricultural sustainability, as this research is less likely to yield marketable inventions for private agribusinesses. The bulk of public and private agricultural science in the United States is narrowly focused on productivity and efficiency, particularly on technologies that fit into existing production systems and lead to private benefits (1, 12). A major vehicle for public agricultural research is the National Institute for Food and Agriculture (NIFA). Despite NIFA efforts to solicit proposals addressing sustainability, most NIFA and other federal research grant programs still primarily support incremental research. What is needed is reallocation of public funds to support transdisciplinary systems research that explores such interlocking issues as farm productivity and resilience at field, farm, and landscape scales (13).

Transition toward transformative agricultural systems currently relies on a smaller, emerging knowledge base developed largely by farmers and nonprofit organizations independent of traditional scientific institutions. Agricultural science and farmers would benefit from an easily accessible information database of farm innovations. Moreover, pilot projects could be funded by reallocation of Farm Bill subsidies to measure multiple sustainability indicators on conventional and innovative farming systems at the landscape or watershed scale (11, 14).

**Final Recommendations**

To make difficult choices among competing goals requires public dialogue about what kind of food and agriculture we want, in addition to identifying the roles of markets, policies, and science in delivering them (15). Successful implementation will require organizations spanning political and institutional boundaries and integrating complex components of agricultural transformation—from research to on-farm implementation, to markets, and to the dinner table. The Green Lands Blue Waters Initiative (16) to achieve “systemic transfor-

**References and Notes**

17. The authors comprise the Committee on Twenty-First Century Systems Agriculture of the National Research Council who wrote the 2010 NRC report (1). We thank L. Klein, J. Glover, and E. Sorensen for comments.