Redesigning Agriculture

GEORGE BOODY AND BRIAN DeVORE

Modern industrial agriculture is incredibly good at the mass production of low-priced commodities. Such single-minded efficiency has given developed countries consistently full supermarket shelves and allowed the world's population to grow from 1.6 billion to more than 6.5 billion in a little over a century. But this has come at a significant cost. The industrial approach relies on a disconnect between crops and livestock and an emphasis on maximizing production to the exclusion of all else. Such a break has created a highly dysfunctional nutrient cycle, one in which massive amounts of nitrogen fertilizers are used to maintain high yields on industrial farms. A significant proportion of those nutrients, along with other pollutants, leaves our farms in the form of water and air pollution. Nitrogen fertilizer escaping midwestern crop fields, for example, is creating a dead zone in the Gulf of Mexico that is undermining the fishing industry there. Agricultural fertilizer in Australia is a major threat to the Great Barrier Reef (Smil 2001), as it is to 146 coastal estuaries around the world (Zimdahl 2006). There is even evidence that excess nitrogen fertilizer is causing declining plant diversity in natural ecosystems such as grasslands (Wedin and Tilman 1996, Smil 2001).

During the past half-dozen years there has been an intensive debate among agriculturalists, environmentalists, scientists, policymakers, and, most recently, nutritionists about how to restore ecological functions to agricultural land. It has become clear that it will require a multidisciplinary approach that goes beyond mere agronomic tinkering. Taken as a whole, five books provide a glimpse at how we can broaden agriculture's narrow preoccupation with yielding a handful of commodities and remake it into a multifunctional process that provides many public goods, including food; functional landscapes; economic development; and ecosystem services such as increased biodiversity and a tight, sustainable nutrient cycle.

In *Enriching the Earth: Fritz Haber, Carl Bosch, and the Transformation of World Food Production* (2001), geographer Vaclav Smil tells the important story of how we got to this point in agriculture. Smil describes how the ability to circumvent the natural nitrogen cycle and create this critical nutrient in a factory has become both a blessing and a curse, a long-term dependence with many negative consequences. Weed scientist Robert Zimdahl, in *Agriculture's Ethical Horizon* (2006), brings facts and a broad, informed set of ethical and philosophical reflections to bear on dilemmas that face scientists and agricultural practitioners. This engaging book seeks to spur the creation of "a firm ethical foundation" for our food and farming system, which Zimdahl argues is essential to advance the practice of agriculture toward sustainability. As Jules Pretty skillfully writes in *Agri-Culture: Reconnecting People, Land and Nature* (2002), there are changes afoot all over the world. Pretty, a professor of environment and society at the University of Essex, provides supporting evidence for a global perspective and place-based stories for how agriculture is being transformed into a multifunctional beast of burden. His informative book makes the case that new approaches are possible and could be expanded if given sufficient credence. Journalist Michael Pollan, in *The Omnivore's Dilemma: A Natural History of Four Meals* (2006), provides an entertaining and firsthand look at how a more localized food and farming system could tighten our nutrient cycle while creating healthier consumers. In *Farming with the Wild: Enhancing Biodiversity on Farms and Ranches* (2003), environmentalist and journalist Daniel Imhoff demonstrates with photos and text that farming can be integrated into systems that protect wildlands.

A world-class discovery

Smil argues in *Enriching the Earth* that when German chemist Fritz Haber successfully synthesized atmospheric nitrogen into ammonia fertilizer on 2 July 1909, he made one of the greatest scientific discoveries of the 20th century. The author provides plenty of evidence to back up his claim. Earth's atmosphere is 80 percent nitrogen, but its atoms are tightly paired and nonreactive, making usable forms of the element scarce in nature (the major source of natural nitrogen is through lightning and specialized bacteria in legumes such as alfalfa). That would be no big deal, except that lack of nitrogen is usually the most important limiting factor in both

George Boody (e-mail: gboody@landstewardshipproject.org) is executive director of the Land Stewardship Project, 2200 Fourth Street, White Bear Lake, MN 55110. Brian DeVore (e-mail: bdevore@landstewardshipproject.org) is editor of the Land Stewardship Letter. *© 2006 American Institute of Biological Sciences.*

crop production and human growth. No wonder that by 1909 the artificial synthesis of nitrogen had become one of the "holy grails of synthetic inorganic chemistry," as Smil puts it.

When Carl Bosch later figured out how to use Haber's method to synthesize nitrogen on a large-scale industrial level, our food and farming system was changed in ways no one could have foreseen. Humans produce at least half of the fixed nitrogen present in the world. In intensively cultivated areas like the Corn Belt in the United States, the Jiangsu rice region of China, and winter wheat areas in France, England, and the Netherlands, manufactured nitrogen accounts for 70 to 80 percent of the total nitrogen inputs. For better or worse, human management accounts for about 80 to 85 percent of the nitrogen added to fields worldwide to support food production—we now dominate the nitrogen cycle.

Perhaps no aspect of the American agricultural system has been affected more by the Haber-Bosch process than corn production. Soon after World War II, chemical plants that produced explosives using the Haber-Bosch process turned to manufacturing massive amounts of fertilizer. Corn requires a lot of nitrogen to thrive, and Corn Belt operations were the perfect customers for this artificial nutrient. Before nitrogen fertilizer became so accessible, the Midwest was traditionally a mix of diverse family farms that produced row crops and small grains such as oats, as well as hay, pasture, and livestock. The livestock—beef and dairy cattle especially—were fed grain and forage that were raised right on the farms. Their manure went back onto the same crop fields that provided their feed, creating a tight nutrient cycle. But as Smil points out, Haber-Bosch changed all that:

> Synthetic compounds eliminated the necessity of returning the nutrient in animal waste to fields in order to sustain new harvests, and they allowed the emergence of highly specialized cropping that is largely, or completely, separated from no less specialized and highly concentrated animal production. Long-distance transfers of fixed nitrogen have replaced this traditional pattern. In plant production the element moves in with purchases (imports) of fertilizers and goes out with sales (exports) of food and feed crops; in animal husbandry it comes in concentrate feeds (often imported from overseas) and goes out in meat, dairy, and aquacultural products. (Smil 2001, p. 240)

Today, US Corn Belt farms are more likely to be specialized cropping operations that raise corn and soybeans, plants that cover the soil only a few months of the year. There is such a narrow window of opportunity for these annual row crops to take up nitrogen fertilizer that half or more of the nutrient is lost after it's applied, finding its way into rivers and underground aquifers, and into the atmosphere as gases. The cycle that circulated nutrients from the land through animals and back to the land again has become a leaky one that can significantly alter ecosystems. This disruption of the nutrient cycle means there is a very fine line separating fertilizer as food production input and fertilizer as ecosystem-damaging waste product.

The crops raised on these specialized farms often find their way to large-scale livestock operations that may be in the next county, the next state, or another country. These operations feed corn and soybean-based feeds—which are cheap to buy in part because of federal subsidies paid to growers—to push production, and produce massive amounts of liquid manure, which is stored in pits or lagoons until it can be disposed of. Even when manure from large-scale, specialized livestock operations is used as a fertilizer, it is often present in such massive quantities that local crop fields can't make efficient use of it. Under such a system, manure is no longer a valuable nutrient, but a waste product to be disposed of. The series of events triggered by the perfection of the Haber-Bosch process is the major reason why agriculture is this nation's leading source of nonpoint water pollution (Wright 1999).

Smil is aware of the perils of a disjointed nutrient cycle, and documents them in great detail. As long as we depend on manufactured nitrogen to produce most of our plant nutrients, these problems are inevitable. But he also argues that without the Haber-Bosch process, two-fifths of the world's population would not be around today. Or, as others claim, we would have had to convert 10 million to 12 million square miles (about 26 million to 31 million square kilometers) more land into crop production (Avery 1997, cited in Zimdahl 2006). Smil sees no effective substitute. Relying on animal manure, legumes, and other natural sources to provide nitrogen for agriculture won't cut it, he posits, and even such technological advances as precision farming to apply fertilizer in a more targeted manner don't show promise for significantly reducing our reliance on the Haber-Bosch process anytime soon. However, Smil sees genetically engineered plants that can more efficiently utilize nitrogen fertilizer as showing the most near-term potential. The irony of using one controversial technology to fix the problems of another seems to have been lost on Smil. Such thinking dooms society to lurch from one technological fix to another until we've undermined ecosystem services to the point where problems outweigh gains from more food.

Smil isn't entirely unaware of the dangers of taking a nonholistic view of our food and farming system. In fact, he uses some interesting numbers to offer a refreshing counterargument to those who claim that there are only two options available: unlimited use of nitrogen fertilizers or mass starvation. By examining trade statistics, Smil shows that without synthetic fertilizers, the United States would cease to be the world's largest exporter of food, and the average American diet would have to change profoundly (fewer products derived from animals fed with fertilized cereal grains, less fatty food, etc.). The result, he indicates, would be not only cleaner water but healthier bodies.

Ethics and philosophy in agricultural science and practice

The case for setting new holistic goals for agricultural science and practice is documented and persuasively argued by Zimdahl in *Agriculture's Ethical Horizon*. Why is philosophy important in the debate about how to properly configure agriculture for the 21st century? Science can quantify the potential impacts of high-yield production. However, it is through ethics and philosophy that decisions about balancing acceptable risks in relation to the scientific, economic, and material gains of those who most benefit can be better informed. Like Smil, Zimdahl credits the Haber-Bosch process for increasing yields, but he adds to the picture by providing an understandable history of development and role of weed science in improving yields.

A select few pesticides have been used since ancient times. But it was the mid-20th century when the development and commercialization of modern herbicides based on organic chemistry took off, beginning with 2,4-D (2,4-dichlorophenoxyacetic acid). Zimdahl integrates ethical arguments for, and challenges to, dominant approaches to research and the practice of weed science.

Zimdahl describes his own beginnings as a budding weed scientist devoted to selected questions, such as "What is the identity of the problem weed?... How can it be controlled,...and what herbicide will be most effective for controlling the weed selectively?" (pp. 131–132). Agriculture's focus on a utilitarian approach has led to great production successes, despite a lack of detailed knowledge of the basic ecology behind plant growth. "Complete life histories of weeds are rare.... Why a weed grows where it does is less important than how to control it," he writes (p. 18). Zimdahl's evolution as a scientist involved painful questioning brought on by deciding not to exclude from his professional purview nagging concerns about the unintended impacts of herbicide technologies in war and in agriculture. His questions were met with admonitions from fellow scientists to keep silent about such concerns and busy himself with the conduct of science. His concerns, though, led him to widen his perspective. Achieving sustainable agriculture will require research, he notes, that must begin with "why" questions followed by empirical "what" questions.

Zimdahl describes the arguments for and against the conduct of agricultural science that focuses on technologies to increase yields. He outlines the arguments of technological optimists such as Avery, Wildavsky, and others. He also documents the consequences of applying these technologies in terms of who farms, how they farm, and how animals are raised. He weaves ethical questions in with descriptions of more inclusive approaches to science advanced by farmers, philosophers, and other academics in and outside of agricultural science, including Berry, Harwood, Kirschenmann, Keeney, Goldschmidt, and Liebman. He quotes, among others, Thomas and Kevan (1993), who wrote that long-term sustainable agriculture cannot simply maximize commodity production per acre. Definitions of sustainability need to shift from an anthropocentric ethic to an ecocentric ethic, Zimdahl states. In other words, "the land and its needs are regarded as coincident with human needs" (p. 212). Zimdahl closes the book by elucidating major issues, including salinity, desertification, loss of farmers, and population growth, commenting on how philosophy of science relates to them. He makes a cogent case for the view that debating the ethics of agriculture and understanding the myths of science are central to progress toward sustainability.

The power of reconnecting farming and local culture

In the past, all agriculture was local by necessity—one ate what could be grown within walkable distance. But a new, purposeful approach to increase locally based food and farming systems will provide much more than food. Local food and farming systems can provide ecosystem services such as cleaner water, open space, and wildlife habitat. They should also provide local jobs and support of local institutions such as schools and places of worship. In other words, such systems should provide a community not only "natural capital" but "social capital," writes Pretty in *Agri-Culture*. He argues that throughout history farming was seen as an integral part of the culture. But with specialization, monocultures, and the increasing urbanization of our society, farming has come to be seen as just one more service industry—a "food factory" in this case. Pretty coined the term "monoscape" to describe the landscape resulting from industrial agriculture operations and its attendant problems. As the wide impacts from our inefficient nutrient cycle and industrial approach to agriculture have emerged, it's become clear we separate "agri" and "culture" at our own risk. A rejoined "agriculture" builds the kind of social capital that "yields a flow of mutually beneficial collective action that contributes to the cohesiveness of people in their societies," writes Pretty. One result of the social capital that has developed around alternative farming systems is that local groups, often feeling overwhelmed by or excluded from the industrial model of agriculture, are coming together to share ideas and support each other. These aren't grand, exciting stories of mass conversions, and Pretty knows it:

> A sustainable agriculture making the best of nature and people's knowledge and collective capacity has been showing increasingly good promise. But it has been a quiet revolution because many accord it little credence. It is also silent because those in the vanguard are often the poorest and marginalized, whose voices are rarely heard in the grand scheme of things. (p. xii)

Pretty describes the integrated pest control strategies being taught and developed through farmer schools in Southeast Asia. Changes had to be made in response to rising losses caused by increasing pesticide applications. Now rice yields have increased by 5 to 7 percent, while pesticide use and production costs have decreased. Fish yields from local ponds are also increasing. Pretty quotes Tim Robertson, a former program leader for farmer field schools in Bangladesh, who talks about the return of frogs to the farms: "Our fields are singing again, after 30 years of silence," says Robertson (p. 93). Pretty tells other stories about salinity farming in Vietnam, and ecological reconstruction in China that integrates local agriculture and small-scale digesters to provide renewable energy and fertilizers.

A saying among farmers in central Tamilnadu, India, is that "the land without a farmer becomes barren." Pretty goes on to describe how the people are working together to redesign fields so that the soil captures monsoon rains instead of allowing water to run off when the land is barren.

Local foodsheds

Enriching the Earth, Agriculture's Ethical Horizon, and *Agri-Culture* make it clear that synthetic nitrogen use could be reduced by reintegrating crop and livestock systems and making locally produced food a greater proportion of the diet. Michael Pollan, a writer well known for his participatory journalism, takes that idea further in *The Omnivore's Dilemma* by taking part in various aspects of America's food production and consumption systems—from the conventional fast-food restaurant version that dominates society, to "Big Organic," to local.

Anyone familiar with Pollan's work and his animosity toward corn-based factory farming won't be surprised when he uses personal experience, facts, and reportage to show the unsustainability of the mainstream food system. More surprising is Pollan's criticism of what he calls "Big Organic" or "Industrial Organic." In order to be certified organic, food must be raised without synthetic chemicals, including fertilizer. On a smaller scale, organic farmers have replaced the Haber-Bosch process with composted fertilizer cooked up right on the farm, green manures generated by plowed-down legumes, and manure produced by livestock present in the area. But industrial-scale organic farming rivals its conventional counterpart in terms of its inefficient nutrient cycle.

Large-scale, specialized organic crop farms are shipping in organic fertilizers and shipping out truckloads of fruits and vegetables. Some dairy companies are using loopholes in USDA (US Department of Agriculture) rules to produce organic milk in large-scale confinement systems that produce millions of gallons of liquid manure waste. Growing food organically uses about a third less fossil fuel than growing it conventionally, Pollan writes. However, that saving is wiped out if the compost used for fertilizer has to be trucked in from off the farm. And only about a fifth of the energy used to get food to our supper tables is consumed on the farm. Processing and transportation burn up the rest (Pollan describes buying organic asparagus that had originated in Argentina). Replacing the Haber-Bosch process with trucked-in turkey manure or soil amendments imported from Europe may reduce some environmental impacts, but is no more sustainable than conventional agriculture in the long term. The organic food industry has come to the point where it is "floating on a sinking sea of petroleum," concludes Pollan.

Pollan is convinced that creating a locally based food and farming system is the only real way to tighten our nutrient cycle and achieve sustainability in the long term. If Iowa farmers aren't shipping raw commodities like corn and soybeans all over the world, then they will need to produce more fresh foods that can be consumed locally, he argues. And when farmers diversify, a reliance on synthetic fertilizers and pesticides will go down, as diverse systems have been shown to produce much of their own fertility:

> [T]here are good reasons to think a genuinely local agriculture will tend to be a more sustainable agriculture. For one thing, it is much less likely to rely on monoculture, the original sin from which almost every other problem of our food system flows. A farmer dependent on a local market will, perforce, need to grow a wide variety of things rather than specialize on the one or two plants or animals that the national market (organic or otherwise) would ask from him. (p. 258)

Unfortunately, when such scenarios are laid out, critics of sustainable agriculture often dismiss them as a desire to return to a sort of peasant farming system where people grubbed a harsh living from the earth. In fact, there never was a "golden age" of agriculture before Haber-Bosch in which noble yeomen purposely struck a balance between nature and food production. As ecologist Laura Jackson has pointed out in *The Farm as Natural Habitat: Reconnecting Food Systems with Ecosystems,*

> what farmers of the early twentieth century had right was more by virtue of constraint than restraint. Farm productivity depended by necessity upon ecosystem services combined with clever manipulation. Nevertheless, the favorable comparisons between prairie ecosystems and early Midwestern agroecosystems suggest that we may be able to design agroecosystems that do an even better—and more purposeful—job at mimicking natural ecosystems while growing our food. (Jackson and Jackson 2002, p. 152)

What sustainable agriculture advocates like Pollan and Jackson are proposing is a post-Haber-Bosch system that utilizes nature's natural processes on purpose. That may mean recapturing some techniques from the old days, but it mostly means moving into new territory altogether. Fritz Haber himself knew the limitations of controlling the nitrogen cycle when, in his Nobel Prize acceptance speech, he said, "It may be that this solution is not the final one. Nitrogen bacteria teach us that Nature, with her sophisticated forms of the chemistry of living matter, still understands and utilizes methods which we do not as yet know how to imitate" (Smil 2001, p. 231).

The wild garden

"Diverscapes," as Pretty calls them, can be quite colorful and pleasing to the eye. The beautiful color photos in Imhoff's *Farming with the Wild* certainly attest to that fact. Imhoff believes we will not reach a fully sustainable level of food production until farms replicate natural ecosystem as much as possible. He sets out to show, with photos and text, how farms across the country are doing just that by "farming with the wild," or utilizing ecosystem services. The large format of this book, with its many colorful photos, would make it easy to dismiss as an artfully done coffee-table tome. But the text that accompanies the photos tells an important story. It describes how "farming with the wild" can work, even providing ways to get started and showing how consumers can get involved by using their food dollars to support certain "green" labels.

At the heart of *Farming with the Wild* are Imhoff's visits with numerous operations across the country that are doing everything from using natural predators to keep insect pests in check to hooking up with other operations to create corridors of natural landscapes. When Imhoff visits the farm of Art and Jean Thicke in the southeast corner of Minnesota, he sees an operation that utilizes natural grassland systems to produce milk. The cattle are rotated through grazing paddocks on a daily basis, where they deposit manure at a rate that the grass can make use of efficiently and in an environmentally sound manner. It's a low-cost and profitable way to produce milk, and it's based on a closed nutrient cycle. The Thickes' farm also provides habitat for grassland songbirds and other wildlife, as well as protecting open land and water resources in a beautiful, but fragile, part of the state. When Imhoff talks to Art Thicke and wildlife biologist Tex Hawkins about what the term "farming with the wild" means to them, Hawkins provides a succinct description of how it works on this particular farm: Thicke "looks to the wild for reinforcement about whether what he is doing is right or wrong. In turn, the wild responds to his adaptive approach" (p. 89).

Actions to reward public goods and production

If farming systems that help the environment and provide other public goods are to thrive, farmers will increasingly need reinforcement from society. The five books discussed here reinforce our own view that several actions will be critical for agricultural development around the world.

The discussion of ethics must be publicly applied to the research and practice of agriculture. As Imhoff, Pollan, and Pretty point out, farmers must make a living at what they do. Unfortunately, neither the market nor public policy adequately provides farmers with the financial or even moral reinforcement they need to provide public goods such as a closed nutrient cycle. Premiums paid for organic products are one financial reinforcement, but as these writers point out, such a market incentive has its limits. Consumers must become "coproducers" (a term coined by Slow Food founder Carlo Petrini)—savvy shoppers who know the value of food raised locally and are willing to pay for that now, rather than pay to clean up environmental damage later.

To be successful, agriculture must rest on a firm ethical foundation that can only be clarified through vigorous debate that includes scientists, farmers, other practitioners, and the consumers of food (Zimdahl 2006). It is insufficient to say that "production is used to justify environmental, human and nontarget species harm" (Dundon 2003, cited in Zimdahl 2006). As Zimdahl and Pretty articulate in thoughtful chapters describing different ethical perspectives, the likely impacts of biotechnology will be significant at ecological and community levels. Can biotechnology be applied within an ecocentric approach to agriculture? This calls for more than traditional stakeholder discussions. It involves rights for future generations (Burkhardt 1989). One of those is the strengthening of "democratic institutions that promote active participation of all people in addressing whatever problems they encounter or set themselves" (Burkhardt 1989, cited in Zimdahl 2006).

New markets for multifunctional products must be developed. There are plenty of goods that don't appear on any label but that people value all the same: aesthetic landscapes, songbird and waterfowl habitat, carbon capture, and community jobs. A public good can also take the form of removing or avoiding the public "bads" currently created by industrialized agriculture: for example, reduced wildlife populations and increased lung disease problems produced by working conditions in livestock confinement, and yes, broken nutrient or hydrological cycles. Ecolabeled food products are expanding. Other ecosystem service markets are in their infancy. We need to find more approaches to pay farmers for ecosystem services on the basis of actual performance (Keeney and Boody 2005).

More quality agroecological and systems research is needed. Can we decrease our reliance on synthetic nitrogen and still feed a human population of 10 billion people by 2050? Research—both on the farm and at universities—shows that integrated farming systems provide real opportunities to reduce our reliance on synthetic nitrogen and pesticides (Liebman 2001, Pretty 2002). But we have much to learn about agroecological systems and the potential multifunctionality of agriculture, while meeting the food needs of a ballooning world population. Such research not only needs to deal with problems we have created but to help us take a proactive approach to the changing agroecosystem dynamics that will result from global climate change. For example, scientists at the USDA's National Soil Tilth Laboratory are finding that the intense rainfalls brought on by climate change are wiping out the benefits created by "cutting-edge" agronomic practices such as no-till agriculture if they are not part of a more complex conservation system. "We have conservation measures that were built for a climate scenario we no longer have," one scientist recently lamented (DeVore 2005, p. 19).

Farm policy must reward public goods. Farmers also need reinforcement from the government for practices that provide services such as a tight nutrient cycle. The United States has a long way to go in that arena. Current US farm policy punishes farmers who seek to diversify out of mainstay commodities like corn, soybeans, cotton, wheat, and rice. As a result, federal farm policy has had a major detrimental effect on the environment, as well as on rural communities. We need a new farm policy that clearly promotes nonmarket benefits as well as marketable products. This policy should provide a clear and strong signal to farmers that society wants them to manage their land in a way that optimizes the balance between long-term public benefits and the production of crops and livestock.

One significant step in the right direction is the federal Conservation Security Program (CSP), which was launched by the 2002 Farm Bill. It pays farmers for using production systems that result in environmental benefits, such as cleaner water and more wildlife habitat. In an article published in the *Agricultural and Resource Economics Review* (Westra et al. 2004), researchers with the Multiple Benefits of Agriculture initiative show that CSP, along with Conservation Reserve Program payments, could help produce significant environmental benefits while buoying farmer income. We have been on farms that are enrolled in the top tier of CSP, and it is impressive how they are using perennial grass systems and diverse crop rotations to produce a good income, as well as numerous ecosystem benefits for their local watersheds and communities. These farms are using income received through CSP to make improvements and to transition even further into sustainable systems.

A program like CSP allows taxpayers to pay for the results they want, rather than paying once for commodities and again for clean-up costs for water pollution. Unfortunately, CSP will have little impact unless it is fully funded and reserves its highest payment rates for resource-conserving crop rotations, sustainable grazing systems, and other conservation systems with high, multiple environmental benefits. The federal Farm Bill is up for renewal in 2007, providing a prime opportunity to strengthen and improve CSP. Pretty extracts examples of policies from a diverse set of countries that are "coordinated and holistic." It is not sufficient to give agriculture a green tinge around the edges, he argues; policies must also find a way to green the "middle of the field." Examples of integrated policies to achieve sustainable agriculture include China's Shengtai Nongye and national policies in Switzerland and Cuba (Pretty 2002). Policies in developed countries also need to be redesigned so that they do not harm smaller farmers in the Southern Hemisphere and so that they produce the intended ecological and social benefits in the developed countries themselves (Vorley 2001).

An emphasis on place and culture is needed. Locally based agriculture can provide ecosystem services that are of great value in particular regions. For example, in the Minnesota River valley, impacts from row crop production have made the river one of the 20 most endangered waterways in America (Mulla and Mallawatantri 1997). In a modeling study, the results of which were published in *BioScience* in January 2005, we showed that farming systems in the Minnesota River watershed that rely on perennial plants such as grass while incorporating hay, small grains, and other resource-conserving crops could significantly improve water quality and provide other benefits (Boody et al. 2005). We also found that through policy changes, benefits could be attained at less cost to taxpayers while benefiting farmers financially. The profitability of farmers in the watersheds rose as the diversity of their farming systems increased. Even though federal Conservation Reserve Program payments for setting aside farmland as a buffer along streams and rivers increased under this scenario, the overall taxpayer cost was lower because of the decrease in commodity payments.

Japanese philosopher Osamu Soda (2006), in the recently released book *Philosophy of Agricultural Science,* describes a "process for increasing total welfare or realizing comprehensive values." The concept provides for balance between ecological values, economic values, and life values in the context of "ba," or place. It is in the local that farmers, research, and policy come together in the context of human community to solve problems and achieve goals.

In coming years, nations, local communities, and individuals will have to make many difficult ethical decisions concerning the competing requirements of agricultural production, ecosystems, economics, and social justice. How we deal with these issues will become even more complicated as societies push for yet another commodity from agriculture: energy. Corn in the United States is being used increasingly for ethanol. It takes synthetic nitrogen and vast quantities of water, which, together with soil erosion and other impacts, amount to a big ecological footprint for resource use and waste assimilation (Dias de Oliveira et al. 2005). Cellulosic digestion of agricultural crops such as switchgrass shows potential as a source of energy (Hill et al. 2006). Will agriculture provide energy in the future from monoscapes of corn, soybeans, sugarcane, and switchgrass, or from diverse landscapes of prairie grasses, forbs, other perennials, or annuals using low chemical and energy inputs? How will societies balance using their agricultural crops for food and fuel?

Responding to such demands in a sustainable way requires us to create holistic, multifunctional farming systems based on the needs, limitations, and resources of communities—human and ecological. An agriculture based on a series of isolated components—crops separate from livestock, farmers distanced from consumers, farming separated from culture, and production systems disrupting ecological processes—won't sustain us into the future. The future of food, the land, and society requires us to make agriculture whole.

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