Editorial

Biodiversity in Agricultural Landscapes: Saving Natural Capital without Losing Interest

While species extinctions continue to be a matter of extreme concern, changes in biodiversity in the world's agricultural landscapes have largely escaped attention. Implicitly, the world community has traded off biodiversity in these landscapes against the conservation of threatened endemics in protected areas. But biodiversity loss in agricultural landscapes also has an opportunity cost. It affects not just the production of food, fuels, and fibers, but also a range of ecological services supporting, for example, water supplies, habitat, and health. Although increasing attention is being paid to the environmental context of modern agriculture, its role in biodiversity conservation has been largely ignored.

The world's population of 6.3 billion people is projected to grow to 9 billion by 2050. To meet the increased demand for food, more land will be converted to agriculture. Irrigated and pasture lands are both expected to double in area by 2050, with a net loss of 10^9 ha of wildlands, thereby increasing the pressure on biodiversity in natural ecosystems. At the same time, farmers are expected to intensify agriculture with increased inputs of fertilizers, pesticides, and fossil fuels. Aside from the loss of diversity of breeds, farm birds, beneficial insects, and soil biota in agroecosystems, agricultural intensification puts wild biodiversity at risk through gene flow from domesticated varieties to wild species, cross-species transmission of potentially virulent pathogens, and adverse effects of fertilizers and pesticides on nontarget species in adjacent wildland ecosystems. In so doing, it changes a wide range of ecosystem services. These include provisioning services that support production of foods, fuels, and fibers; regulating services such as pollination and pest control; and supporting services such as nutrient cycling and water purification.

How should the problem be resolved? The economists' approach is at least suggestive. Biodiversity is part of our natural capital, and the flow of ecosystem services on which we depend is the interest on that capital. Just as private investors choose a portfolio of produced capital to maintain the return on capital over a range of market risks, so society needs to choose the mix of genes, species, and ecosystems to maintain the flow of ecosystem services over a range of risks for environmental quality and human well being, including poverty alleviation. Doing so requires that we understand the risk implications of changes in that mix and use that understanding to inform conservation strategy. At the moment, there is no evidence that such an understanding exists. For example, market prices offer farmers little incentive to conserve biodiversity, and international conservation efforts are concentrated on the protection of biodiversity hotspots or ecoregions and pay almost no attention to agriculture. Although recent reforms of Europe's Common Agricultural Policy indicate that in some parts of the world the situation is changing, in general the prospects are gloomy for both biodiversity conservation and sustainable agriculture.

Part of the problem lies in the scientific information available to decision makers. Science has not yet addressed the trade-offs between food production, biodiversity conservation, ecosystem services, and human well being in agricultural landscapes. Nor has it addressed the trade-offs between biodiversity conservation efforts in protected areas versus human-dominated landscapes. We offer three conjectures. First, the underutilization of the vast majority of species holds the promise of innovations not just in pharmaceuticals, but also in the production of food, fuels, and fibers. Biodiversity is not a threat to agriculture; it is the key to its sustainability. Second, the overutilization of just a few species (genotypes) in agriculture results in the need for pesticides and other inputs that harm nontarget biota. Biodiverse agriculture is not a threat to wildland biodiversity; it may substantially increase the chances of its survival. Third, the failure to recognize the wider role of biodiversity in agricultural landscapes means that insufficient attention has been paid to the risks associated with the loss of important ecosystem services. Biodiverse agriculture provides services that increase the ability of the Earth's biota to respond to climate and other environmental risks.

What do these conjectures mean for biodiversity science? The international program of biodiversity science, DIVERSITAS, has identified a scientific agenda for biodiversity use in agricultural landscapes that points in the right direction (http://www.diversitas-international.org/). Three key research objectives integrate biological and social sciences: (1) assess biodiversity in agricultural landscapes and the anthropogenic drivers of biodiversity

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change; (2) identify the goods and services provided by agrobiodiversity at various levels of biological organization (e.g., genes, species, communities, ecosystems, and landscapes); and (3) evaluate the options for the sustainable use of biodiversity in agricultural landscapes.

This agenda requires new approaches for the quantitative assessment of biodiversity and the ecosystem services it supports. Geneticists, ecologists, anthropologists, and economists need to work across ecosystem boundaries to understand the environmental and social drivers for biodiversity change in agricultural landscapes. Innovative methods for data handling and analysis across disciplines are required, as are protocols for integrating formal and informal knowledge. The recorded decline in agrobiodiversity in many communities is matched by the decline of the informal knowledge associated with it. The interface between agricultural and wildland ecosystems is of special interest because factors that promote utilization of agrobiodiversity, stable human livelihoods, and poverty alleviation will likely result in less biodiversity loss in neighboring wildland ecosystems.

The science plan argues for a fundamentally different approach to the science and management of agricultural landscapes, considering them not just as systems of production, but as systems that provide a range of services of which the production of foods, fuels, and fibers is just one. The science plan makes a case for understanding how biodiversity-rich agroecosystems can increase food production over the long term while reducing the impacts of agriculture on wild species and, in fact, extending their ranges and contributing to their survival.

The science plan assumes that biodiversity is part of our natural capital, and if ecosystem services are the interest on that capital, science must then help identify which components are important for managing future environmental and socioeconomic risks; the level of conservation effort (investment in biodiversity) should depend on both the mean yield of the portfolio and the covariance in yields over the long term. If different species vary in their sensitivity to environmental or socioeconomic changes, then reducing the variety of species included in the portfolio increases the risk borne by society. Lower diversity increases average yields—at least in the short run—but also increases risk. Conversely, greater diversity reduces overall risk, but at the potential expense of lower mean yields.

We believe that science should help us evaluate the trade-offs between agricultural productivity, ecosystem services, and human well being more effectively than has been the case in the past. We need a science that evaluates the biodiversity externalities of particular institutions, market structures, and property-rights regimes. We need a science that recognizes the interdependence between human behavior and ecosystem processes and that delivers a deeper understanding of the value of biodiversity for our life-support services over the long term. Because habitat loss due to the expansion and intensification of agriculture and forestry is currently argued to be the main threat to biodiversity in wildlands, biodiversity conservation in agricultural landscapes may be the best solution both to the protection of species worldwide and to the growth in production of foods, fuels, and fibers. We need a science of biodiversity in agricultural landscapes that is at least able to test that hypothesis.

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