Agricultural Intensification: Will Land Spared from Farming be Land Spared for Nature?

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How can intensive agricultural systems be designed so that they have fewer and smaller impacts on surrounding ecosystems? This is not a new challenge, but its importance to conservation—particularly in developing regions—has become apparent in recent years. This challenge is a major part of the ongoing effort to provide for the needs of a growing human population and at the same time sustain the life-support systems of the planet (Vitousek et al. 1997; National Resource Council 1999). To many in the conservation community, a growing human population makes the goal of harmonizing food production and conservation all but impossible. That psychological landscape has changed fundamentally, however—the end of human population growth is within sight over most of Earth (the peak population will be realized sooner and at a lower level with intensified, committed effort). Nevertheless, population will continue to grow for some decades. In many areas, standards of living and levels of nutrition will (and should) increase. What are the best ways to meet the dual challenges of agricultural production and conservation?

Many agronomists suggest that the best way to meet those challenges is through intensifying agriculture and increasing yields on the “best” lands. That way, the necessary production can be obtained on the smallest area of land and more land can be “saved for nature” (Waggoner 1995). Intensification leading to increased yields per hectare provided most of the last doubling of agricultural production—and the potential for another doubling in yields now attracts both debate and research. An alternative pathway by which agricultural production and conservation could be harmonized is wildlife-friendly farming, which involves designing agricultural systems so that they support important components of biological diversity within the agricultural landscape itself.

Recent analyses by Green et al. (2005) and Balmford et al. (2005) evaluated these alternatives regionally and globally. If there is some decrement in per-hectare agricultural yield from wildlife-friendly compared with intensive agriculture and if the relationship between land-use intensity and measures of diversity is concave (upward) for a substantial number of species (both reasonable assumptions), then more bird diversity (in their analyses) could be sustained by partitioning land between intensive agriculture and reserves than by practicing wildlife-friendly farming. They demonstrate that with sustained rapid growth in per-hectare yields (something that is not assured), most of the increased food demand in developing regions can be met from the current area of agricultural land, although some new land will be required. (Given similar assumptions—and reasonable levels of trade—developed countries may require a little less agricultural land than at present.) They conclude that conservationists should pay as much attention to increasing per-hectare yields of food crops as we do to human population growth and rates of consumption.

We believe that the essential features of their analysis are correct, at least in biophysical terms. Agricultural intensification and continuing increases in per-hectare yields could offer more promising pathways for conservation of biological diversity in regions with accelerating demands for food than could wildlife-friendly farming. The biophysical potential for enhancing conservation, however, is not enough. Intensive agricultural systems must be purposefully developed so that they actually spare land for nature, not merely make it possible.

We focus here on two ways in which intensive agricultural systems often fail to spare land for nature. The first is that such systems affect much more land (and water) than they actually incorporate. Regions downwind or downstream of productive areas are influenced by such factors as diversion of water and inadvertent inputs of fertilizer or pesticides. The second is that agricultural intensification begets extensive land use, both by displacing people...
and by providing economic attractants for migration into the area.

The first of these concerns is recognized fairly widely (reviewed in Matson et al. [1997], Tilman et al. [2002], and elsewhere), and its importance is acknowledged by Green et al. (2005) and Balmford et al. (2005) (who also point out that wildlife-friendly farming is not without its own off-site effects). It remains, however, a critically important area for research and action in conservation biology. For our interests—for the good of the world—it is not enough that agricultural yields continue to increase as they have in the past. Intensive agricultural systems require inputs—often of water, always of nutrients and pest control—and those inputs must be used much more efficiently within agricultural systems than is now the case so that losses from them do not reduce the capacity of downwind and downstream ecosystems to support biological diversity. This is an area in which economic and conservation values should be in alignment; fertilizers that do not go to the crop represent an expensive waste to the farmer and are a threat to surrounding environments.

Ecological research can play an important role in the design of intensive agricultural systems that have less impact on their surroundings. In the Yaqui Valley of Mexico, an interdisciplinary group involving ecologists, economists, agronomists, hydrologists, and others has (1) determined the environmental consequences of the inefficient use of nitrogen fertilizer within intensive wheat agroecosystems on the atmosphere, downwind systems, and the Sea of Cortez (Matson et al. 1998; Beman et al. 2005; Harrison et al. 2005); (2) characterized the policy environment that led to the development of the inefficient system that is in place and that has allowed it to flourish (Naylor et al. 2001); and (3) developed an alternative set of agronomic practices that produces just as much grain of equal quality with less inputs of fertilizer and far lower consequences to surrounding ecosystems at substantially lower cost to farmers (Matson et al. 1998). Despite the agronomically, environmentally, and economically advantageous results, adoption of the new approach (and its derivatives) has been slow. The group is now focusing (in part) on the knowledge and decision systems underlying farmers’ adoption of new technologies and on the development of site-specific information that reduces farmers’ uncertainty in decision making. Similar efforts are under way elsewhere, and they could be replicated widely.

Our second area of concern—the association of intensive agriculture with expansion into unmanaged systems—represents an equally serious challenge. Intensification rarely takes place in a social vacuum. Intensive agricultural systems generally replace extensive ones, and the people who farmed that land before intensification often move to nearby or distant marginal lands and cultivate them extensively (Kaimowitz & Smith 2001). Also, the overall increase in economic activity in an intensifying agricultural region frequently leads to demand for a variety of products and services (including animal production systems) and to in-migration, population growth, and associated land use outside the intensive agricultural lands (see Angelsen and Kaimowitz [2001] for a compendium of case studies illustrating these points). These processes expand the footprint of intensive agriculture at least as strongly as the fertilizers and pesticides that move from agricultural fields to the environment.

How can these challenges be addressed? We believe that increasing agricultural yields through intensification is both necessary and potentially environmentally beneficial. It must be done more knowledgably than it has been in the past, however, with increased precision in the use of inputs and dramatic reductions in inefficiencies and losses. Equally important, we need to view agricultural systems as integral parts of landscapes. Agricultural intensification should be considered part of a complete system—not merely as a set of crop yields in isolation—and analyses should account for the human and the environmental consequences of its development. Conservation biologists have important roles to play in this conversation.

**Literature Cited**


