Diversity

Yes, We Got Some Bananas

And oranges, and wheat, and apples, and maize, and grapes, and rice, and broccoli. You name it. These crops, like most other commercially important agricultural commodities, are grown primarily in monocultures that extend for thousands of hectares. In the case of bananas, for example, most plantations occupy fertile alluvial soils that once supported what were probably the richest and most magnificent of tropical forests, a biotope that is now virtually extinct. Thus, they are an extreme example of landscape simplification. On the other hand, bananas have just become Costa Rica's number-one foreign currency earner, an important consideration in a country with one of the world's highest per-capita debts.

As conservationists, should we marshall our forces against monocultures? Should we tolerate them as a necessary, albeit unpleasant, economic reality? Or should we encourage them as high-yielding systems that take some of the pressure off of pristine ecosystems? Most of us would opt for one of the first two alternatives; few would favor the third.

Monocultures include such a broad array of crops and are employed in such a wide range of environments that accurate generalization is impossible: annual grains have replaced prairie; pine plantations have replaced oak woodlands; shrimp ponds have replaced monospecific mangrove forests; and bananas have replaced diverse forests. Nonetheless, before judging monocultures, it may be useful to examine some widely held tenets.

Monocultures and Diversity

There is no argument to be made here. Monocultures are—etymologically and ecologically—the antithesis of diversity. There are reports in the forestry literature of increases in plant species richness following conversion to plantations, but such increments are usually the result of either of two factors. First, disturbed sites, such as newly established plantations, are often invaded by short-lived plants that are unlikely to be permanent components of the new ecosystem. Weed diversity does, in fact, increase as a result of conversion, but the species involved are seldom those that merit or require special efforts for conservation.

The second cause of increases in diversity is an artifact of sampling and scale: the density of small plants (those most likely to abound after conversion to plantations) is far greater than that of large plants, such as the trees that might have comprised the preplantation forest; thus, it is not surprising that a hectare of weedy plantation might contain more species than a hectare of adult trees.

Vulnerability to Pests

Plant a vast area to a single plant species—or worse yet, to a single genotype—and devastating pest outbreaks are certain to follow, right? Sometimes. Southern corn blight, Sigatoka disease (of banana), and Irish potato blight quickly come to mind. Even though many pests are controlled through chemical prophylaxis, it seems remarkable that such epidemics are so infrequent when one considers that hundreds of thousands of square kilometers are planted to annual-crop monocultures such as wheat, soybeans, and rice each year.

Part of the explanation may be that plants, including peas, have not read Mendel. They have a great propensity to undergo somatic change in their genetic makeup, such that vast monocultures derived from single-source cuttings, cultured tissues, or genetically uniform seeds may in fact include a substantial amount of genetic variability. Furthermore, crop breeders often select primarily for architecture and yield, so a substantial amount of genetic heterogeneity remains in traits related to pest vulnerability.

Short-lived plants have an additional defense. They escape many of their pests because the sporophyte oscillates back and forth between adult and seeds about once a year.

The story for perennials is different. Long-lived adults are, in effect, semipermanent targets for pests. In most forests, a few tree species are quite abundant, and these are presumably well defended. Most species, however, are sparse, and these may escape pests by being inconspicuous. When locally rare species are concentrated in monospecific plantations, the probability of a successful hit by a pest increases dramatically, and once introduced, the organism can spread contagiously among neighboring plants. Familiar examples include South American leaf blight in rubber, pine bark beetles, monilia on cocoa, and leaf rust of coffee. Diversity might well dilute the targets and thus reduce the vulnerability of perennial crops to pests.

Herbivorous insects are commonly assumed to be the villains of greatest concern, but trees are stationary, and insects have both mobility and finely tuned guidance systems. Thus, many trees seem to be moderately well defended against folivores. It is the microbes—the bacteria, fungi, and viruses—that often are the most devastating agents of destruction in perennial monocultures. Bananas, coffee, and cocoa are sprayed to control fungi, not insects.

Complementarity

It is a cherished tenet of polyculturists that mixtures of species use a site's resources more thoroughly than a single species. Sometimes they are right. But to a great extent, all plants feed out of the same trough: they all convert the same wavelengths of solar energy; they all require carbon dioxide, water, and oxygen; and they all take up the same suite of mineral nutrients.

Temporal partitioning of resources is the most common form of complementarity. Spring wild flowers beneath deciduous trees are a familiar example from nature, and relay cropping is a common example from agriculture. But what about a continuously growing, densely packed banana plantation? There is no ground cover, but is there sufficient light and water for a shade-tolerant understory crop? Why not coplant a tall tree that casts little shade? It might yield another crop, tap nutrients from different soil strata, and augment animal diversity. Or it might simply compete head-on with the bananas. The jury is still out on these questions. We do not, in fact, know whether two or three or four or forty species of plants grown together will lead to enhanced efficacy of resource use.

Fossil Fuel Demands

Since 1973, when the political forces in control of the world's oil supplies first tweaked the valves, the dependency of modern agriculture upon petroleum has become all too apparent. Much can—and must—be done to improve the efficiency of on-farm energy expenditures, including the design of appropriately scaled machines and those capable of dealing with mixed cropping schemes. Nevertheless, agriculture is probably the soundest investment we can possibly make with our dwindling supplies of fossil energy. No other enterprise enables us to parlay so much solar energy into so much badly needed productivity, thanks to photosynthesis.

Is the success of monospecific plantings an ephemeral artifact of cheap fossil fuel subsidies for agriculture? In one sense, yes. Large-scale monocultures lend themselves to big machines, uniform irrigation regimes, and species-tailored applications of fertilizers and pesticides. Yet there is nothing unique to monocultures that makes them particularly great sinks for fossil-energy subsidies. There are mixed-species horticultural operations throughout the world, ranging from vegetables in Taiwan to flowers in the Netherlands, that are far more fossil-fuel intensive than many large-scale monocultures.

In the absence of fossil fuels, none of our current modes of commercial agricultural production are sustainable. I, for one, would prefer to see my tiny share of the world's remaining fossil energy consumed by food production, storage, and distribution, and on the design of ecologically sound systems—including monocultures if these prove best—than on military exercises or space shuttles.

Need for a Balanced View

Agribusiness has opted for large-scale monocultures for reasons that are primarily managerial and economic, not ecological. Production of a single commodity facilitates horticulture, processing, and marketing, and lends itself to economies of scale. Simplicity is easier to manage than complexity at almost any scale, regardless of fossil-fuel use. Even backyard gardens usually have a monospecific row or two of this followed by a couple of rows of that, each a linear monoculture in its own right. Why? Because horticulture—planting, weeding, manuring, harvesting—is easier.

Furthermore, the risks associated with monocultures can be absorbed by well-financed corporations. When an earthquake recently rocked the Atlantic lowlands of Costa Rica and Panama, a group of banana company executives quickly presented the president of Costa Rica with a million-dollar check. The transportation network to the coast was soon repaired, fruit again flowed to the port, and the price of bananas in my local supermarket dropped about 30 percent (back to normal) in a matter of weeks. Smallholders who produce bananas in remote areas could only have weathered such a natural tragedy if they had spread risk through diversification into crops not so dependent on well-scheduled transport to market.

And that brings us back to diversity. It is essential as a risk aversion tactic; it is desirable as an ecological feature. Diversification must be addressed and created at many scales, ranging from within-field polycultures to land-use mosaics at the landscape level. Mimicking the structure and function of natural communities in our agricultural systems may be an ecologically desirable way to proceed, but it is fraught with horticultural and managerial pitfalls.

Granted, extensive monocultures have a bad reputation among environmentalists, one that may be well-deserved. Nevertheless, well-meaning conservationists often overstate the case in headline-grabbing accusations that are seldom based on data: bananas impoverish the soil, they accelerate erosion, they are doomed to failure due to pest outbreaks. Such ill-informed evangelism endangers the credibility of all conservationists and, in the longer term, serves no useful purpose. There is a sound biological and economic basis for the observation that monocultures feed the world, either directly in the case of grains, pulses, and starches, or indirectly in the case of cash crops. The biological cost of these dreary, homogeneous stands is high, for we have replaced complexity with simplicity. Nevertheless, without them, vastly greater quantities of land would have to be devoted to agriculture and forestry if we are to make any reasonable attempt to feed and shelter the populace of this overpopulated world.

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