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The Necessary Marriage Between Ecology and Agriculture

by Wes Jackson and Jon Piper

Our subject here is "the problem of agriculture" not "problems in agriculture." We proceed with the assumption that problems *in* agriculture are primarily derivatives *of* the problem of agriculture. Soil erosion beyond replacement levels is an agriculture-old problem. And though the synthetic chemicals accumulating in the soil and waters of our land are a recent event, their use is a consequence of our ancient attempts at pest control, a major feature of our struggle to stay ahead of famine since agriculture began. Even though our increasing fossil-fuel dependency for traction and fertility may be a product of the industrial age, in the main it represents our most recent response, a mere detail in the long history since the time those most-revolutionary-of-all ancestors scaled their patches upward to the level of fields. Even the problem of narrowing the germ plasm in our major crops is not a recent phenomenon. Those first few cuts of selection by humans may well have yielded the steepest decline in germ plasm in the history of crop evolution.

In a real sense, then, we live in a "fallen world": the nature that produced us - particularly nature's ecosystems which fed and clothed us as we gathered and hunted - has been almost totally destroyed or seriously damaged during the 8,000-10,000 years of agriculture. We *have* really changed the face of the earth.

The major feature of this split with nature, then, has been the exercise of human cleverness in transforming earth's landscapes to yield an abundance of food and fiber. This "human cleverness" approach to the world stands at the opposite end of the spectrum from the application of "nature's wisdom." The problem of agriculture, therefore, lies at the very core of the human condition. Is it not time to give emphasis to another tack? For even though humans may learn faster than nature, natural plant and animal communities have been shaped by climatic and evolutionary histories beyond complete human comprehension. After all, we recognize now that such concepts borrowed from industrial models as producer, consumer, and competitor are inadequate to convey accurately the complex relationships within natural ecosystems.

Those who settled the North American continent brought with them visions of a European-style agriculture in which their familiar crops and livestock could thrive and satisfy markets in the homeland (Crosby 1986). Tragically, as the New World ecosystems were dismantled, stabilizing processes were decoupled, and species were extirpated before their roles in the ecosystem could be understood sufficiently. In short, as Wendell Berry (1987) has said, "We have never known what we were doing because we have never known what we were undoing." The few relicts of pre-Columbian vegetation that remain must serve as our best standards by which any agriculture touted as sustainable is to be judged.

There are barriers to be overcome if we are to shift the ratio more toward the ecological or "nature's wisdom" end of the spectrum. Most fundamental, perhaps, is the fact that nearly all of us, whether we are scientists or not, are not only full-time participants in, but endorsers of the very approach that created the "fall" in the first place. We operate as though we must greatly bend nature to meet human demands. Francis Bacon, the father of modem science, simply gave that notion a formal endorsement in his projection of the potential benefits of science. His younger colleague Ren□Descartes effectively advocated that the way to carry out this scientific mission is to place priority on the *parts* of things over the *whole.* Civilization in general, perhaps western civilization in particular, provided an umbrella for the specific practitioners of reductionistic science.

Since it is ecology-to-the-rescue we are promoting here, we must acknowledge a second, though perhaps less major, barrier. Modern ecology has suffered from the Baconian-Cartesian paradigm world view, too. It was Tansley (1935) who insisted that ecologists isolate the basic units of nature and split up the story into its individual parts. Ecological scientists yielded to his call even though ecology, perhaps more than any other discipline in biology, lends itself to a dialectical approach (Levins and Lewontin 1985).

Paradoxically it is the Cartesian knowledge and data accumulated in the last 50 years or so that we can now call upon as our primary body of knowledge to use in narrowing the split between humans and nature. This "knowledge on the shell" was mostly accumulated for its own sake, but sits there ready to be used and expanded upon by those interested in regarding nature as the standard in their design of sustainable agroecosystems.

There are problems, of course. Nature is ill-defined, and natural ecosystems are dynamic. But the patterns and processes discernible in natural ecosystems still remain the most appropriate standard available to sustainable agriculture. Liberty Hyde Bailey (1915) and Sir Albert Howard (1943) were early scientific advocates of such an approach. Howard went so far as to say we should study the forest in order to farm like the forest, and he devoted the last half of his distinguished scientific career to try to understand that end. These men have been largely ignored by both ecological and agricultural scientists who continue to try to improve agriculture by understanding it in its own terms rather than by acknowledging that, ultimately, it comes out of nature. A few contemporary scientists, however, are attempting to model agroecosystems on nature's standards in the desert southwestern United States (Nabhan 1985), the North American prairie (Jackson 1985, Piper and Gernes 1989), and tropical forest (Hart 1980).

The present state of agriculture in the developed and rapidly developing countries is one with several problems beyond soil erosion, fossil-fuel dependency, chemical contamination of the countryside, and genetic narrowing of our major crops. Family farms are being lost and rural communities are in decline - both consequences of the loss of capital from rural areas; this "cleverer-than-nature" approach rewards primarily the suppliers of inputs. Beyond the government subsidies to the suppliers of inputs (with the farmer laundering the money), cited by our institutions for stabilizing our so-called food production system, is the looming problem of biotechnology. It gives false hope because it is simply a further exercise of reductionist biology in a way that accelerates our antagonism toward nature. The natural integrity of a forest or prairie is unlikely to be considered by biotechnologists at work. This multibillion dollar industry (with

no obvious embarrassment) makes extensive claims about some future utopian agriculture in which food production falls into the hands of increasingly fewer people. Many of its enthusiastic promoters have a non-ecological point of view; they regard livestock and crops more as human property than as relatives of wild things that had most of their evolution in a context not of our making. They also do not consider the secondary effects of their work. The new biotechnology, in other words, is simply an extension of the old biotechnology of plant and animal breeding with emphasis on production. For example, animal scientists apparently fail to factor into their equations the fact that the bovine growth hormone, intended simply to increase milk production, will also put numerous dairy farmers out of business. Or consider that an arthritic, cross-eyed hog at Beltsville, Maryland, with rapid weight gain and leaner meat resulting from a spliced-in gene for a human growth hormone, is less pitied as a living creature and more viewed as a nothing-but-hog object in need of some fine-tuning. The primary monsters biotechnology is bound to create may well be those humans who see nothing wrong with forcing farmers into cities and livestock into pain and misery.

To overcome such problems *in* agriculture, relying on such narrowly focused research agendas alone will benefit primarily the suppliers of industrial inputs. Relying on an ecological perspective - nature's wisdom - will likely benefit rural cultures and landscapes. What is needed are countless elegant solutions keyed to particular places, which a more dialectical or inherently ecological perspective offers.

It has been well said that what ecology can offer agriculture is not a set of easy answers, but rather a series of difficult questions (Dover and Talbot 1987). Short of that, various subdisciplines of ecology offer entry points for workers in sustainable agriculture. For example, the development of perennial grain crops requires application of evolutionary theories on life history strategy and resource allocation. Such potential crops as *Agropyron intermedium, Leymus racemosus,* and *Desmanthus illinoensis* can produce yields approaching agronomic suitability (Burritt 1986, Piper et al. 1988, Wagoner 1988, Kulakow et al. 1989). Long-term demographic models of change in size-structured populations are relevant to stands of perennial crops that will spend years between disturbances. Polycultures designed to benefit from spatial, seasonal, and nutritional complementarity among species draw largely on studies of plant interference and facilitation in natural communities. Diverse cropping systems that encourage biological management of herbivores, weeds, and diseases require application of our knowledge of trophic interactions and models of pathogenesis. Truly sustainable agroecosystems, that is, those relying primarily on sunlight and locally derived nutrients, should reflect to a great extent the patterns of succession, energy flow, and nutrient cycling that occur in natural ecosystems.

Agricultural science has something to offer ecology, too. Ecologists have had the luxury of being descriptive, while agriculturists have necessarily had to be prescriptive. Agroecology will have to be a prescriptive discipline. While ecologists have retreated to study their bogs and alpine meadows, agriculturists have been forced to include the social, political, economic, and even religious realms within their boundary of considerations. Just as a plant species bred in monoculture may behave unpredictably when grown in polyculture, sustainable agroecosystems cannot be isolated from their cultural contexts (see Chapin 1988). And although agroecologists in their prescriptions will have to consider the bottom line, various non-economic factors will need to be given equal or greater weight in such formulations before we can conserve soils, species,

and ecosystems while sustaining a vital agriculture. Such issues as productivity, diversity, and stability of agroecosystems are well suited to hybrid research agendas.

The full range of benefits arising from blending ecology with agriculture is unforeseeable. For example, if one regards native species and habitats as necessary standards against which to judge our agricultural practices in the future, then the argument for their preservation is widened to include economics. The science of ecology will benefit. Consider, too, the seminal studies of plant demography, competition, and community structure that derived from the work done on agronomic species or in pastures by British ecologists in the 1960s and 1970s. Or consider that the soil community remains a largely unexplored wilderness for ecologists. Overall, there is bound to be an increased breadth and meaningfulness within the discipline of ecology, and the job prospects for young ecologists should improve.

It has only been since the advent of agriculture that humanity has so heavily depended on some form of extractive economy, which lies at the core of the human condition. Properly matured and seasoned, ecology can address most of the problems that are derivatives of this condition. Because humans are primarily social land animals, our real space program must feature land, community, and people as one thing. We should take heart, for it is not just ecologists who know the story. At some level nearly everyone knows that care of the earth is our real work, more than shuttling into space of bioengineering for some ideal feedlot hog.

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