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Intensive Agriculture and Environmental Quality:

Examining the Newest Agricultural Myth

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The challenge facing agriculturalists, environmentalists, and others concerned about the sustainability of world agriculture, is how to meet the food needs of between 8-10 billion people in the next century. Even though enormous efforts have been made to enact policies and develop education programs designed to slow population growth, experts now generally agree that we must face the sobering fact that world population is expected to grow by 100 million people a year for the next 30 years. Most of this increase will be in the developing world. [1]

It is not surprising, given these projections, that much attention is being focused on what is called "high-yield" agriculture as a necessity for feeding a growing world population. Unfortunately, some proponents of high yield agriculture present this approach in overly simplistic, "either-or" terms. They suggest, for example, that we must rely entirely on pesticides, commercial fertilizers, other chemically-based inputs, and high energy use in land intensive crop production systems, or face the prospect of low per acre yields requiring an expansion of production into marginal land areas, or create a new world food crisis.

This faulty logic is used by Dennis Avery, a particularly aggressive proponent, to further suggest that chemically-based, high-yielding, intensive agricultural systems are the key to protecting wildlife, natural ecosystems and biodiversity, while feeding the world's population.[2] There may be, for some, a naive beauty in stating that chemically-based intensive agriculture will meet all of our production and environmental goals, but this is dangerously misleading. In fact, it can best be characterized as the newest agricultural myth.

John F. Kennedy noted that, "Mythology distracts us everywhere—in government as in business, in politics as in economics, in foreign affairs as in domestic policy." As the federal budget is tightened, it is critical that we do not let this newest myth distract decision makers from the search for and extension of efficient, productive, and environmentally friendly agricultural production alternatives. If modern science can map the human genome, send a satellite to Jupiter, and transfer genes from animals to plants, then certainly we can find ways of increasing crop yields with fewer chemicals and other environmentally threatening inputs and practices. Scientific research has already shown that many practices and systems associated with sustainable agriculture have helped farmers achieve increased yields and profits with reduced reliance on pesticides or purchased nitrogen fertilizers. Yet there is more to be learned and applied as we look toward the 21st century.

Avery's argument, and the myth it nurtures, hold up only under two highly questionable, underlying assumptions: (a) that alternatives to a chemically-based crop production system necessarily requires more land to produce the same amount of output; and (b) that the adverse ecological and health consequences of a chemically-based, land intensive system are minor in comparison to those that would be wrought by expansion of land extensive production systems.

The purpose of this paper is to present well documented evidence that challenges these assumptions, thus refuting the myth and preventing the undesirable effects of its acceptance. We do this by pursuing two general areas of counterevidence. First, we document the fact that the widespread adoption of chemically-based, land intensive crop production systems has had environmental effects which are not only costly in their own right, but which also actually have hindered attempts to provide adequate food for a growing world population. Second, we highlight the results of sustainable agriculture research, and the experiences of some major practitioners of alternative production systems, to demonstrate that these techniques could increasingly be available to meet future global food needs while improving environmental quality.

Finally, we challenge the agricultural research and business communities to investigate the full range of all possible pathways towards the goal of producing adequate food supplies for as many as 10 billion people in the next century. Because no one technological paradigm or class of production systems is likely to prove optimal over all locations and circumstances, a failure to pursue all the alternatives, and the possible synergies among them, is tantamount to irresponsibility.

In a Nutshell...

The Myth:
Chemically-based, land intensive agricultural systems are the key to feeding the world's growing population and their use will, at the same time, enhance wildlife habitat, biodiversity, and unique ecosystems.

The Myth's Assumptions:
The myth does not hold up unless you believe that...

- Alternatives to chemically-based crop production systems necessarily require more land to produce the same amount of output; and
- The environmental benefits of limiting land used for crop production outweigh the environmental costs associated with chemically-based crop production systems.

Counterevidence:
Scientific data and expert knowledge which challenge the assumptions on which the myth relies (and, thus, refute the myth itself) include the following:

- Proof that while some terrestrial ecosystems may benefit from restrictions on agricultural uses, many aquatic and marine systems—increasingly important sources of food as well as biodiversity—are suffering from the consequences of chemically-based systems;
- Demonstration of a range of negative effects of chemically-based, land intensive crop production on terrestrial ecosystems, which may well outweigh the benefits of restricting production on marginal lands;
- Documentation of declining yields and/or offsetting production costs associated with intensive chemical use on "Green Revolution" crops; and
- Mounting confirmation that a range of alternatives to the chemically-based production model can achieve equivalent or higher yields per unit of land area.

Dangers of the myth:
Widespread acceptance of the myth, in light of the evidence against its validity, can preclude investment in R&D on environmentally friendly alternatives to chemically-based production models and discourage agricultural businesses from making strategic decisions about products and services likely to be demanded by future farmers. Ultimately, the myth could impede progress towards achievement of an agricultural system that will feed a growing world population without endangering the natural environment.

The ecological impacts of chemically-based, intensive agricultural systems are serious and costly.

The range and magnitude of adverse consequences associated with runoff and leaching of nutrients and pesticides, and the environmental risks posed by certain agricultural chemicals, discredit blanket claims that chemically-based, intensive agriculture is environmentally friendly. The nature of several consequences of such systems also brings into question their net food production benefits. For example...

Chemical contamination and eutrophication (from runoff of excess nutrients, mainly nitrogen and phosphorous, from cropland) threaten the productivity of the marine and aquatic systems from which a substantial portion of the world's food supply derives.

- Fully sixty percent of the world's people receive more than 40 percent of their annual protein from fish and seafood.[3] And evidence suggests that fish and seafood, unlike many native food sources in less developed countries, are *not* "inferior goods," for which demand recedes as incomes rise. In fact, in highly developed countries, including the United States, demand for seafood is growing at higher rates than that for meat. USDA estimates that fish and seafood expenditures in the U.S. will increase 20.8 percent between 1990 and 2005, exceeding its projected rates of increase for beef, pork, and poultry over that same period.[4]

- Aquatic and marine habitats and productivity are highly vulnerable to the residuals from chemically intensive cropping systems. Extensive research and management experience have clearly documented the inextricable link between land use and the health of aquatic ecosystems.[5] Runoff of agricultural chemicals and/or animal waste from farmland is particularly damaging to estuarine systems, the principal source of harvested seafood, because dilution is minimal there. For example, in the Chesapeake Bay, which receives 38 percent of its nitrogen and 53 percent of its phosphorous from nonpoint (largely agricultural) sources, loss of native sea grasses and subsequent reductions in juvenile fish and shellfish populations are linked with eutrophication and blamed for a 96 percent reduction in oyster populations from levels 100 years ago.[6] Half of the fish kills off the coast of South Carolina between 1977 and 1984 were attributed to pesticide contamination.[7]

- **Thus, any increased food productivity attributed to chemical-intensive crop production and highly concentrated livestock operations must be weighed against the potential for consequent loss of food productivity from affected marine and aquatic systems.** Arguments about the most environmentally sound approach to feeding a growing world population cannot be restricted to land-based production alternatives. The world's oceans have the potential to provide far more of the world's food supply than at present. And, compared to the production of other proteins, responsible seafood production results in less environmental impact.[8]

While terrestrial wildlife habitat may be lost by expanding agricultural acreage, wildlife populations both on and off sites of chemically-based intensive agricultural practice have been adversely affected by exposure to agricultural chemicals and/or wildlife-antagonistic agricultural land use patterns.

- Chemical use in agriculture has been identified as the cause of reduced biodiversity in and around agricultural areas. It has been well documented that the decline of predatory birds in the United States during the 1960's and 1970's was linked to agricultural pesticide use. Researchers in the James River area of Virginia estimate that, even as late as 1991, at least six percent of the breeding population of bald eagles was being killed annually from secondary insecticide poisonings.[9] A review of the scientific literature cites more than 50 sources documenting adverse effects of pesticide use in the U.S. on a wide variety of avian, mammalian, and amphibian wildlife populations.[10]

- Increased field size, a corresponding decrease in fencerow and other field-separating land uses, and reductions in the variety of crops produced on farms in the Midwestern U.S. are responsible for dramatic declines in native bird populations such as prairie chickens, bobwhite quail and ring-necked pheasants. [11] [12] [13]

Loss of terrestrial biodiversity associated with chemical and land intensive agricultural systems can actually reduce food production efficiency, and have other negative impacts on commercially valued activities.

- A benefit-cost analysis of granular carbofuran use on rapeseed in Canada shows that when the insect control benefit of this material is compared with the value of insect control losses directly associated with songbird kill rates attributable to this application, the use of granular carbofuran actually represents a net loss to the Canadian economy. [14]

- On a broader scale and of immediate significance to feeding the world's population is a classic example of pesticide-provoked counterproductivity related to reduced biodiversity: the case of brown planthopper on rice. MacArthur Award-winning researcher, Peter Kenmore, has shown how insecticide use exacerbates rather than controls brown planthopper infestations by killing off the pest's natural predators at higher rates than the pest itself. Paradoxically, seven times as many planthopper eggs survive on experimental fields treated with pesticides as on those which remain untreated. As a result of these findings, their effective extension to Indonesian farmers, and supportive government policy; new, low chemical input rice management practices have been widely adopted in Indonesia, where rice production has increased 10 percent while "pesticide use is down sharply." [15]

- A study of Illinois agroecological status found that the expansion of row crop farming and its associated decrease in oat-hay rotations explains over 90 percent of a roughly 50 percent decline in small game taken by hunters, and demonstrates how land intensive row cropping can thwart state-level recreation and tourism-based economic development efforts. [16]

The human health risks of pesticide-dependent, intensive agricultural systems are decidedly nontrivial.

Human health effects of pesticide use, now well documented, are costly in terms of human lives and quality of life, and, as we explain below, can actually reduce food production efficiency. Justifiable uncertainty about the potential for as yet undiscovered human health impacts of agricultural pesticide use also manifests itself in the marketplace.

Human occupational exposure to pesticides is a significant cause of deaths, worldwide, and is suspected to contribute to serious long-term and chronic health hazards in developed as well as developing countries.

- The World Health Organization estimates that there are a minimum of three million acute, severe cases of pesticide poisonings and 20,000 unintentional deaths each year related to pesticide use in agriculture, worldwide. [17] A closer look at available statistics suggests this is an underestimate: In fact, as many as 25 million Third World agricultural workers may be acutely poisoned each year.[18]

- Epidemiological research has determined that farmers are at a higher risk for certain types of cancer than the general population. The greater incidence of cancers such as soft tissue sarcoma, non-Hodgkin's lymphoma, and stomach cancer has been linked with exposure to pesticides and nitrates. For example, agricultural use of phenoxyacetic acid herbicides (particularly 2,4-D) "has been associated with 2- to 8-fold increases of non-Hodgkins lymphoma in studies conducted in Sweden, Kansas, Nebraska, Canada, and elsewhere." [19]

The occupational health hazards associated with pesticide use can reduce agricultural productivity.

- For example, a study conducted by the International Rice Research Institute (IRRI) demonstrates that "pesticide use in the Philippines cuts rice productivity instead of improving it when the associated health costs are counted as a production cost." The IRRI researchers found that losses of farm worker productivity which were directly attributable to dangerous pesticide materials and unsafe pesticide use practices, more than offset the gains in productivity achieved from the pesticides themselves. [20] While it is true that better management of the pesticides may have preserved rice productivity gains while greatly (or wholly) reducing health-related rice productivity losses, it must be recognized that food production throughout much of the world is performed by farmers who do not have access to appropriate advice or decision rules on the sophisticated technologies increasingly available to them.

Consumers' desire for reduced chemical use in food production is clear, justifiable, and evident from market trends.

- In early 1995, a national Gallup poll showed that about one third of the U.S. population strongly disagrees with the statements that "The current levels of agricultural pesticides and fertilizers in the food supply are safe" (29% strongly disagreed) and "The current levels of pesticides and fertilizers in the water supply are safe" (33% strongly disagreed).[21]

- While such public opinion is sometimes cited by traditional agriculturalists as an unfair indictment of "the safest food supply in the world," the public clearly believes that higher standards of safety are possible and desirable. Ongoing public concern, uncertainty, and caution are bolstered by periodic reports from unassailable sources which suggest that there is not yet adequate scientific evidence to either prove or disprove the safety of the food supply as related to prevalent agricultural chemical use patterns. For example...

    - A committee of the National Research Council recommended that pesticide residue tolerance levels for food need to be adjusted to appropriately represent differences in risk to infants, children, and other population subgroups that vary from an "average" adult, suggesting that some groups may not currently be protected by public policy from pesticide health risks.[22]

    - Scientists only recently demonstrated that metabolites of DDT, the pesticide which has probably received more study than any other modern agricultural chemical, are responsible for decreased fertility rates in men.[23] Such new findings clearly justify the suspicion that we still have much to learn about the safety of common agricultural chemicals.

    - Ongoing public concern is reflected by sharp growth in the market for organic foods. According to the sixth annual Organic Market Overview, the U.S. organic foods industry grew more than 22 percent, to a value of 2.3 billion dollars, in 1994, the sixth year in a row that market has seen annual growth rates of 20 percent or more. [24]

Chemically-based, land intensive agricultural systems do not guarantee high productivity. They may not even sustain high yields.

In previous pages we cited evidence that reduced biodiversity and pesticide-related farmworker health problems can make chemically-based, land intensive systems less productive.

In fact, new, improved (Green Revolution), high-yielding varieties in intensive cropping systems have a range of agronomic, economic, and environmental disadvantages that impede food productivity goals.

- Highly accelerated development rates and growth in importance of formerly unknown or unimportant insect-borne viruses of rice are symptomatic of problems in Green Revolution rice varieties grown throughout the world. [25]

- The sustainability of chemically-based pest control is threatened by rising rates and ranges of resistance to chemical pesticides. For example:

  - The estimated numbers of pesticide resistant pest species, worldwide, are at least 504 insects and mites, 87 weeds, and 100 plant pathogens. [26] This can be an acute problem in some food production ecosystems. In Southeast Asia, for instance, eleven different species of rice-eating insect pests have shown resistance to one or more pesticide types, leaving few options for yield loss prevention in the context of intensive production of new rice varieties.

  - Resistance of a rapidly accelerating number of weed species to multiple herbicide types suggests a diminishing rate of herbicide efficacy. According to experts in this field, the nature of herbicide resistance development is such that its "effective management... depends on reducing selection pressure for evolution of resistance, which of necessity involves reducing the frequency and amount of herbicide applied and increasing reliance on integrated pest management practices."[27]

Yields of some important, intensively produced food crops are actually declining, even as we face the probability of increased population pressures.

- A disturbing trend of declining rice yields is being observed in a number of Asian locations. For example, average wet-season rice yields were lower in 1990 than in the early 1980's in several Philippine provinces. Furthermore, yields on the International Rice Research Institute's (IRRI) experimental plots have been declining despite optimal treatment under the conventional, intensive production model and continual replacement of outlived varieties with new improved ones. IRRI researchers suspect a decline in soil quality related to continuous submersion of the same acreage as a possible reason for observed yield stagnation and declines in the Philippines, India, and other locations. [28]

Sustainable and/or alternative agricultural production techniques often compete with and sometimes outshine their conventional counterparts.

Sustainable and/or alternative agricultural research has led to tremendous reductions in the negative environmental impacts of agriculture. In some cases, practices and systems associated with sustainable agriculture have out-produced conventional agriculture even though only a fraction of federal research dollars is spent on research targeted at increasing the productivity of sustainable agriculture.

Sustainable agriculture is a highly sophisticated system of production that uses many state-of-the-art technologies.

A recent survey of the research projects funded under the Sustainable Agriculture Research and Education (SARE) program highlights a variety of highly technical and innovative production systems.

- ***A new soil test reduces nitrogen use***—In New Jersey, a pre-sidedress nitrate test has been developed that can help field corn farmers *maintain yields* while reducing nitrogen application rates by an average of 40 pounds per acre per year—a savings of 12 dollars per acre. The test was designed to help farmers who use either chemical fertilizer or manure, reduce the chances of groundwater contamination. [29]

- ***New machinery kills cover crops without herbicides***—Agricultural engineers at Ohio State University have modified a type of agricultural machine, an undercutter, to kill cover crops without herbicides. Cover crops are often used in sustainable agricultural systems as a source of organic nitrogen but they have also been shown to *conserve moisture and suppress weeds* as effectively as herbicides. [30]

- ***IPM reduces pesticide applications***—Researchers in Georgia were able to show apple growers that by using IPM and a scouting program they could reduce spraying and pesticide costs by about 50 percent. Pest control costs were reduced from 247 dollars per acre per year to 99 dollars per acre, with *no reduction in yield*. [31]

- ***Bacteria found to control tomato pests***—Researchers in California and Arizona found that some tomato diseases were greatly controlled by using a bacterial control agent called *Pseudomonas cepacia*. The bacterial agent controlled one of the leading tomato diseases, Pythium root rot, better than standard synthetic chemicals. [32]

- ***Organic systems control major agricultural pest***—Researchers in Florida and Texas learned how to control the sweetpotato whitefly (a pest that destroys over one billion dollars worth of crops globally each year) by studying natural controls on organic farms. While conventional farms were being ravished by whiteflies, nearby organic producers had inconsequential populations. [33]

Integrated pest management has significantly reduced chemical use.

- According to data collected by the U.S. Cooperative Extension System's Integrated Pest Management Coordinators, more than 40,000 farmers in 32 states have made significant reductions in their use of synthetic chemical pesticides by implementing practices associated with sustainable agriculture. For example, 2,300 cotton growers in Alabama are now using several production techniques associated with sustainable agriculture such as crop rotation, pest scouting, biological pest control and pest resistant varieties to control pests. These practices have allowed farmers to reduce their use of insecticides by 40 percent while maintaining yields.[34]

Research suggests that sustainable agricultural systems may reduce farmers' economic risk due to variations in weather.

- In 1993, Japan's conventional rice crops were nearly wiped out by an unusually cold summer while naturally farmed rice yielded 60-80 percent of the annual average. Nature Farming, a type of sustainable agriculture, is a method of production based on ecologically sound agriculture.[35]

- A nine year study in South Dakota suggests that production from alternative agricultural systems is more stable than production from conventional systems over a range of environmental stresses.[36]

While organic agriculture is only one of many forms of sustainable agriculture (many sustainable systems use agricultural chemicals in appropriate ways) the economic performance of some organic systems suggests that the equation of high yields or high economic returns with chemical use is entirely invalid.

- The multibillion dollar Gallo Wine Company grows more acres of crops organically than anybody else in America. In the last four years, Gallo converted 6,000 of its 10,000 acres of wine grapes to strictly organic methods. A spokesperson noted that it cost more to farm organically during the first couple years of the conversion, but now the ecology of their vineyards is finally in balance, and this year *Gallo produced as many grapes as ever for less money per acre than they did in the chemical days*. [37]

- Virtually all kiwis from New Zealand will soon be organically produced because growers prefer their cultivation to that of treated kiwis and can produce them for the same price. Furthermore, a University of California study shows that organic kiwis have a considerably greater shelf life, and thus greater market potential, than their nonorganic counterparts.[38]

Sustainability and profitability are clearly compatible.

- In examining how well each of 72 alternative Midwestern U.S. cropping systems meets the multiple, ranked preferences of farmers (for high net returns, first, and on-farm resource conservation second), and of environmental protection decision makers (ranking low levels of pesticides and nutrients in surface waters first, other environmental concerns at lower rankings, and high net returns as desirable but lowest ranked), researchers found that systems characterized by low input use and minimum tillage are preferred "regardless of whether profits or preserving the environment is a first priority for the decision maker."[39]

The challenge: bringing high-yield and sustainable agriculturalists together to face the demands of the future.

"Attempting to solve one problem in isolation may be inappropriate. For example, exclusive attention to meeting food needs can exert a very high, perhaps irreversible, toll on the environment and can make it more difficult to meet food needs in the future. Similarly, a sole focus on preserving the natural resource base can condemn millions to hunger and poverty. Linkages and synergies between problems and solutions must be creatively exploited for the world to be a better place."
(Pinstrup-Anderson and Pandya-Lorch) [40]

In previous sections, we show that chemically-based, land intensive agriculture does not necessarily protect wildlife, biodiversity, or water quality. We also provide examples to show that sustainable agriculture outperforms conventional agriculture in some regions and for some crops. This is, of course, only part of the story. Clearly, there are many examples where chemically-based, high-yield agriculture has provided tremendous environmental benefits by protecting marginal lands and allowing people to live off fewer acres. Likewise, in many sustainable agricultural research trials, yields are lower (usually between 5 and 10 percent) than their conventional counterparts. However, what is really needed to produce enough food for 10 billion people in a way that does not devastate the environment is a combination of both types of production. ***The key to production in the next century is high-yield, sustainable agriculture.***

Feeding a growing world population without further endangering the natural environment depends upon public support of high-yield, sustainable agriculture research, education and extension. Alternatives to both chemical-intensive, high-yield agriculture and to land extensive sustainable agriculture can be expected to result from scientific endeavors dedicated to their discovery and development. Only a fraction of the billions of research dollars spent over the last fifty years has been devoted to increasing the productivity of sustainable and/or organic production systems and current funding is being threatened by proposed federal budget cuts.

The demands to dramatically increase food production in the next century may also require a re-evaluation by proponents on both sides of the debate. Farmers, consumers, researchers and others in support of sustainable agriculture will need to evaluate the role that emerging technologies (*e.g.*, precision farming and biotechnology) may play in helping meet food needs at a reasonable environmental and social cost. Likewise, proponents of high-yield agriculture will need to recognize that scientifically valid alternatives to chemically-based agriculture exist and can and should play a vital role in developing the production systems of the twenty-first century.

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