# The importance of high farm yields to wildlife conservation

D. T. Avery

Director of Global Food Issues,
Hudson Institute, Indianapolis, U.S.

**Abstract**

The biggest danger to the world's wildlife is not from pesticides or urban expansion, but habitat loss due to the expansion of low-yield farming. Agriculture already requires 36% of the world's land area. World food demand will at least double within the next 50 years due to a combination of 50% increase in population (peaking at 8.5 billion) and diet improvement. If science and technology had not increased crop yields since 1960, an additional 10-12 million square miles of wildlands would already have been lost to food production. In order to continue to safeguard wildlands, we must have global free trade in farm products so farmland resources are used most efficiently, as well as drastically increased spending on agricultural research to increase productivity as the principle wildlife conservation efforts for the 21st century.

**Key words**

Wildlife, pesticides, food demand, population growth, free trade, conservation, soil erosion, biotechnology, gene banks.

## Introduction

The biggest danger facing the world's wildlife is neither pesticides nor population growth. Naturalists agree that the biggest threat to wildlife in the 21st century is the potential loss of its habitat. Conversion of wildlands into farmland is the major impact of humans on the natural environment, and poses a great threat to biodiversity. (Dobson, et al, Science, 1997) About 90 percent of the known species extinction have occurred because of habitat loss. (Edwards, 1996)

Thus the biggest danger facing wildlife is the potential plow-down of much of the world's remaining forests to produce low-yield crops and livestock. Food needs have always governed the world's land use. Today, our cities take only 1.5 percent of the earth's land area, but farming already takes 36 percent of it. (World Bank, 1997)

The world after 2040 must be prepared to feed a peak population of 8.5 billion affluent people. Few of them will be vegetarian. Without higher yields, the world could lose the forests that still cover one-third of the earth's surface. The Green Revolution has been honored for preventing massive Third World famine -- but its vital role in protecting wildlife habitat has scarcely been recognized by the public. (Borlaug, 1986)

## Saving Room for Wildlife With High-Yield Farming

If science and technology had not effectively tripled world crop yields since 1960, humanity would already have plowed an additional 10-12 million square miles of wildlands for low-yield crops. (Avery, 1997a).

In 1992, the world consumed 115 percent of the grain-equivalent calories consumed in 1960. At constant yields, this would have required the conversion of an additional 6.17 million square miles of wildlands -- even if the additional land has been as productive as existing croplands. Only a little of the additional land would have been irrigated for top yields; I assumed a 50 percent increase in irrigation from 1960 rather than the 27 percent increase which actually occurred. The additional non-irrigated land would have been poorer, because we're already farming most of the best land. Moreover, most of the additional acres would have been in the Third World, where farmers have gotten far less support from research,

infrastructure and government policies. I concluded the additional non-irrigated land would have been only 70 percent as productive as existing croplands.

This is no precise estimate, but it indicates the general magnitude of the natural resources the world would have lost without the Green Revolution: wildlands equal to the total land area of the United States, Europe and Brazil.

Modern agriculture has saved additional millions of square miles of wildlands with a variety of other high-tech agricultural contributions. Among them:

- Substituting tractors and diesel engines for draft animals which require year-round forage and grain supplies -- and thus compete for cropland with food and fiber crops. (In the 1930s, America's adoption of the gasoline tractor is reported to have released another 50,000 square miles of land for cash crops.)
- Producing the world's growing meat supplies from confinement hogs, chickens and cattle rather than by taking major amounts of additional land for pasture. (If the U.S. produced its chickens today on free range, it would take the equivalent of all the cropland in the State of Pennsylvania.)
- Improving livestock and poultry feed conversion ratios through better genetics and improved feed rations.
- Lowering livestock death losses with modern veterinary medicines and vaccines.
- Saving more of the yields achieved through modern food processing, storage and transport.

All told, modern farming and food processing are evidently saving something close to 20 million square miles of wildlands. (The poorer-quality land which would be cleared would have considerably lower yields than the land currently farmed, especially since little of it could be irrigated.)

We could raise the world's crop yields even higher if we liberalized farm trade, and allowed each crop to be grown wherever in the world its yields would be highest and its production costs the lowest. Instead, with hybrid seeds, chemical fertilizers and pesticides, we have continued to crop the same 6 million square miles of land, even though 80 percent more people are eating more than twice as many grain-equivalent calories.

High-yield farming has not only saved land, it has saved the land with the most biodiversity. The best farmlands have the fewest wild species per square mile. (Huston, 1993) Researchers are finding more bird and butterfly species in a few square miles of tropical rain forest than exist in the whole of North America. (Scientific American, 1997) By 2040, we must be able to triple the yields on the world’s existing farmland. (McCalla, 1994) Otherwise, we may lose millions of square miles of wildlands and a huge proportion of our wild species.

The Failure to Invest in High-Yield Agricultural Research

Unfortunately, the world is not gearing up its science and technology resources to meet this conservation challenge. U.S. funding for agricultural research has been declining for decades in real terms, though the cost and complexity of the research projects continue to rise with the size of the challenge. The Federal and State governments spent $1.02 billion on agricultural research in 1970, $1.6 billion in 1980, $1.65 billion in 1990, and $1.8 billion in 1996. Adjusted for inflation, however, the public spending actually declined, from $1.6 billion in 1970 to only $1.l billion in 1990. (Huffman and Evenson, 1993) Even beyond that decline, an increasing share of the public funding has been shifted in recent years toward organic and "sustainable" research designed to foster low-yield farming with fewer inputs.

U.S. private sector agricultural research spending has probably also declined in real terms. Between 1970 and 1990, the private sector increased its nominal research spending from $1.175 billion to $3.15 billion, but in constant dollars there was a slight decline. (Huffman and Evenson, 1993) If the nominal upward trend of the 1980s (+ 3.7 percent per year) has continued, the private sector may now be spending about $3.23 billion per year -- still less in real terms than in 1970.

Overseas, the research funding picture is worse. Europe has never spent heavily on agricultural research. Only a few of the Third World countries (including Brazil, China, and Zimbabwe) have even sporadically spent the few millions of dollars needed for adaptive research to their own farms.

The worst demonstration of the world's low priority on agricultural research occurred in 1994, when the U.S. and other donor nations failed to come up with $300 million for the budget of the Consultative Group on International Agricultural Research (the agricultural research network for the Third World). Thus global agricultural research almost literally "went bankrupt" at the very moment the world was pledging another $17 billion for condoms and contraceptive pills in the Cairo Population Conference. (The World Bank, at some political risk, stepped in on a semi-temporary basis to keep the CGIAR research network from collapse.)

The U.S. Agency for International Development has historically provided about 25 percent of the research funding for the CGIAR. In the 1960s and 1970s, that meant about $60 million per year. Despite the centers' success in raising world crop yields, USAID has since shifted sharply away from agricultural research, toward family planning. Given the sharp downward trend already achieved in Third World birth rates, additional family planning funds are likely to make only a modest difference in the world's population -- but Western intellectuals and journalists highly approve of population management.

Today, USAID provides only about $30 million in much-cheaper dollars per year to the international research centers – only 10 percent of their budget.

The Agriculture Committee of the U.S. Senate recently proposed a "dramatic" proposal to increase American agricultural research spending by $1 billion over five years. This would increase the country's Federal research funding by more than 10 percent. (Senate Agriculture Committee, 1997)

The whole world's agricultural research investments, public and private, may well be less than $10 billion per year. This is a tiny level of research, given that the American food industry alone produced $782 billion worth of goods and services in 1996. (Agricultural Outlook, 1997)

By comparison, the U.S. has been spending nearly $100 billion per year on political transfer payments to its farmers. The European Union is currently spending $150 billion per year on its farm subsidies. (OECD, 1995) The U.S. Environmental Protection Agency has just imposed new U.S. air quality standards for particulate matter which will cost an estimated $60 billion (the President's Council of Economic Advisors) to $360 billion per year (the Center for Public Choice at George Mason University). This may save the lives of 15,000 elderly asthmatics per year.

Agricultural research, meanwhile, has saved perhaps 1 billion human lives from famine; increased food calories by one-third for 4 billion Third World residents; and prevented millions of square miles of wildlands from being plowed down.

Should We Recommend Low-yield Farming?

It is hard to see how a world facing the biggest surge in food demand it will ever see – and which wants to keep its wildlands -- needs more research on low-yield farming. Yet the environmental movement is recommending organic and traditional farming systems which have sharply lower yields than today's mainstream farms.

A recent organic farming "success" at the Rodale Institute achieved grain-equivalent yields from organic farming that were 21 percent lower, and required 42 percent more labor. (Hanson et al, 1997) The public has been told the organic approach is "kinder to the environment." The public has not been told that its low yields would force us to destroy millions of square miles of additional wildlands.

`Environmental magazines extol the "virtues" of traditional peasant farming, though its yields may be one-tenth those of modern farming. Meanwhile, the International Center for Forestry Research warns the planet might lose up to half of its tropical forests to primitive slash-and-burn farming.

Greenpeace and the World Wildlife Fund have gathered millions of European signatures on petitions to ban biotechnology in food production. They do not protest biotechnology in human medicine, to keep more people alive longer; they only protest biotechnology in food production where it will help produce more food from less land, and thus save more room for nature.

Factors in High-Yield Farming Disapproval

We shouldn't be too surprised at the lack of approval and funding for agricultural research. The First World countries, which have funded most of the modern farming research, have been surrounded for the past 40 years with highly visible surpluses of grain, meat and milk. Too many citizens now associate the farm surpluses with science, not with ill-conceived farm price supports and trade barriers.

Western Europe watched its farm population decline from about 20 percent in 1960 to about 5 percent today. This followed an earlier but similar decline in U.S. farmer numbers. Both Europe and America associate the decline of the small family farm with the rise in crop yields, not with the rising value of off-farm jobs. Since the publication of Rachel Carson's Silent Spring in 1962, First World residents have been bombarded with claims that modern farming was killing wildlife, endangering the health of children, and poisoning the topsoil. Perhaps most damaging of all, the First World public has become far more afraid of an overpopulated planet than of famine in faraway places. Most of America has apparently been frightened by The Population Bomb. Dr. Norman Borlaug, awarded the Nobel Peace Prize in 1970 for his role in the Green Revolution, is now publicly criticized for keeping too many people alive! (Des Moines Register, 1997)

Stabilizing Population with Food Security

Modern medicine and food availability have lowered the world's death rates, producing a one-time population growth surge. But both also help in the longer term to restabilize population – by giving parents confidence their first two or three children will live to adulthood.

Increased food security, for which crop yields are the best proxy, has been a vital element in sharply reducing world fertility rates. Births per woman in the Third World have already fallen three-fourths of the way to stability since 1965, from 6.1 births to 3.1. The long-term equilibrium for affluent, urban societies seems to be 1.7 births per woman. As a result, demographic trends now indicate a peak world human population of about 8.5 billion people, reached about 2035. (Seckler and Cox, 1994)

The countries that have raised their crop yields the fastest have generally brought their births per woman down the fastest:

- Indonesia has increased its rice yields since 1960 by 250 percent. Its births per woman dropped from 5.5 to 2.9.
- China has tripled its rice yields and quadrupled its wheat yields as it reduced its births per woman from 6.4 to 1.9.
- Zimbabwe has more than doubled its corn yields with Africa's best plant breeding program, while births per woman have dropped from 8 to 3.5.
- Countries without higher yield trends have kept higher fertility rates:
- Ethiopia has suffered famine and civil war, while its births per woman have *risen* from 5.8 in 1965 to more than 7 today.
- Rwanda, where extreme crowding recently helped bring on tribal genocide, has stagnant corn yields and its fertility rate has fallen from 7.5 only to 4.9.

(Yields from FAO Production Yearbooks, fertility rates from World Bank Development Reports)

There is No "Vegetarian Solution" in Sight

If population growth stopped this hour we would probably have to double the world's farm output just to provide the meat, fruit and cotton that today's 5.9 billion people will demand in 2030 when virtually all will be affluent.

Humans might be able to meet their nutritional needs with less strain on farming resources by eating nuts and tofu instead of meat and milk. So far, no society has been willing to do so. America's Vegetarian Times published a recent, reputable poll showing that 7 percent of Americans call themselves vegetarians. Two-thirds of these "vegetarians" eat meat regularly, and 40 percent eat red meat regularly. Virtually all of them eat dairy products and eggs. Less than 500,000 Americans are vegan, foregoing all of the costly livestock and poultry calories. The vegetarian/vegan percentages are similar in other affluent countries. Meanwhile, in what used to be the "poor" countries, the demand for meat, milk and eggs is soaring along with the incomes.

- China has been raising its meat consumption by 10 percent annually in the past six years. Chinese consumers are currently eating an additional 5 million tons of meat per year, equal to more than 20 million additional tons of feedstuffs. (USDA/FAS, 1990-97)
- India has doubled its milk consumption (to 65 million tons). Two-thirds of its Hindus indicate they will eat meat (though not beef) when they can afford it.
- Indonesia's flock of broiler chickens jumped 25 percent in 1995 alone, from 450 million to 600 million.

It will not be possible to stave off disaster for the wildlands with so few vegans, and with even vegetarians consuming large amounts of resource-costly animal and poultry calories – unless we continue to raise farm yields.

To make room for low-yield farming, tropical forests are being burned and plowed, and wild species are being driven from their ecological niches. Indonesia is clearing millions of acres of tropical forest for low-quality cattle pastures and to grow low-yielding corn and soybeans on highly erodable soils – for chicken feed. World Bank experts say India is getting one-third of the fodder for its millions of dairy animals by stealing leaves and branches from its forests. Forests throughout the tropics are losing up to one-half of their species because bush-fallow periods have been shortened to feed higher populations. (Banerjee, 1994)

There are no plans, nor any funding, for a huge global vegan recruiting campaign. Nor does history offer much hope of one's success.

The Potential for Higher Crop Yields

The world now has only one proven, effective strategy for protecting its wildlands in the 21st century: getting higher yields of crops and livestock from the land we're already farming.

Pessimists have been telling us since the late 1960s that we won't be able to continue raising the yields. However, we've managed to raise world grain yields by nearly 50 percent in the meantime. If we'd taken the pessimists' advice to scrap agricultural research when they first offered it, the world would already have lost millions of square miles of wildlife habitat we still have.

Nor is there any objective indication that the world is "running out of farm technology."

- World grain production had hardly increased at all between the 1991/92 crop year (1,706 million tons) and 1995/96 (1,708 million tons). But the strong farm price incentives produced by low grain stocks and high prices generated an extra 150 million tons of grain in 1996/97, from mostly-sustainable sources. (USDA/FAS, 1997)
- World corn yields are continuing to rise as they have since 1960, at about 2.8 percent annually, in what's rapidly becoming the world's key crop. (USDA/ERS) The yield trend has gotten more

erratic – mainly because droughts cost more yield in an 8-ton field than in a one-ton field. U.S., corn breeders are now shooting for plant populations of 50,000 plants per acre, three times the current Corn Belt planting density – and 300-bushel yields.

- *Science* recently noted a potentially huge new breakthrough from biotechnology. Two Mexican researchers have inserted a gene to let crop plants secrete citric acid from their roots. This allows them to tolerate the aluminum toxicity which currently cuts crop yields by up to 80 percent on 30 to 40 percent of the world's arable land. (*Science*, 1997.)
- The International Rice Research Institute in the Philippines is re-designing the rice plant to get 30 percent more yield. Researchers are putting another 10 percent of the plant's energy into the seed head (supported by fewer but larger stalk shoots). They're using biotechnology to insert resistance for pests and diseases. (International Rice Research Institute, 1993) The new rice will be genetically engineered to resist the tungro virus (humanity's first success against a major virus).
- Two researchers from Cornell University reported in the Aug. 22, 1997 issue of *Science* that they boosted tomato yields 50 percent by inserting genes from wild relatives of the tomato plant. They also inserted two wild-relative genes in the top-yielding Chinese rice hybrids, and each produced a 17 percent yield increase in test plots. This implies there is major yield gain to be had from using wild-relative genes to broaden the genetic base of virtually every crop plant.
- The U.S. Food and Drug Administration is close to approving pork growth hormone – which will produce hogs with half as much body fat and 20 percent more lean meat, using 25 percent less feed grain per hog! Globally, that will be equal to another 20-30 millions tons of corn production per year, produced essentially from laboratory bacteria.
- Meanwhile, traditional breeding programs continue to produce crops with higher yields and greater tolerance for disease and stress. Livestock breeders are getting more milk per cow and a higher percentage of twin calves. Poultry breeders are achieving still-better feed conversion and still-lower death losses. All of these trends will be speeded and amplified by biotechnology.

*And if humanity succeeds only in doubling instead of tripling farm output per acre, the effort will still save millions of square miles of wildlands.* Thus, pessimism about agricultural research is an excuse, not a reason, for failing to invest in agricultural research. In fact, the more pessimistic we feel about agricultural research, the more eager we should be to raise agricultural research investments.

The world has gotten strong productivity gains from virtually all of its investments in agricultural research. The problem is mainly that we haven't been investing much.

Sustainability Through Soil Protection

Modern high-yield farming is both the most productive and the most sustainable in the history of agriculture. Throughout history, soil erosion has been by far the biggest problem with farming sustainability. But tripling the yields on the best cropland automatically cuts soil erosion per ton of food produced by about two-thirds. It also avoids pushing crops onto the steep or fragile acres. Now, in addition, farmers have used chemical weed killers to invent conservation tillage systems, which the Soil and Water Conservation Society credit with cutting soil erosion per acre by another 65 to 95 percent. "Conservation tillage" eliminates the moldboard plow, and discs the crop residues into the top few inches of soil. This creates millions of tiny dams against wind and water erosion.

In no-till farming, there is no plowing at all, and the soil is never exposed to the elements. The seeds are planted through a cover crop that has been killed by herbicides. Both systems are rejected by organic farmers because they depend on chemical weed killers, not plowing and hoeing, to control weeds. In addition to saving topsoil, conservation tillage produces far more earthworms and subsoil bacteria than any plow-based system. (Earthworms and soil bacteria hate being plowed.) (Zaborski and Stinner, 1995)

These powerful conservation farming systems are already being used on hundreds of millions of acres in America, Canada, Australia, Brazil, and Argentina. They have even been tested successfully in Africa. The model farm of the future will use still-more-powerful seeds, conservation tillage, integrated pest management along with still-better veterinary medications. It will use global positioning satellites,

computers and intensive soil sampling ("precision farming,") to apply exactly the seeds and chemicals for optimum yields – with no excess to leach into nearby streams.

Even then, high-yield farming will not offer zero risk to either the environment or humans. But it will offer near-zero and declining risk, more than offset by huge increases in food security and wildlands saved.

Three Key Strategies for the World

Agricultural research is the biggest and most important of the three key strategies for retaining the world's biodiversity.

Liberalizing farm trade is the second key strategy, so we can use the world's best farmlands for as much output as possible. Without liberalized farm trade, densely-populated Asian countries will be tempted to try for too much domestic food production, for reasons of politics, chauvinism and misguided interpretations of food security.

- In reality, countries *reduce* their food security with self-sufficiency; the droughts and plagues that cut crop yields are regional, not global.
- Asia in 2030 will have about eight times as many people per acre of cropland as the Western Hemisphere. It already has the world's most intensive land use. Asia's economies are growing twice as fast as the First World.
- Asian countries are currently providing about 17 grams of animal protein per capita per day for 3.3 billion people. (FAO, 1992) Europe and North America are eating 65-70 grams. Japan, which not long ago ate less than 20 grams, is today nearing 60 grams. By 2030, the world must be able to provide 55 grams of animal protein for 4 billion Asians – or they will destroy their own tropical forests to produce it themselves.
- The countries most likely to increase their farm output in the 21st century *without sacrificing wildlands* are outside of Asia: the United States, Argentina, Brazil, Canada, Turkey, France, Poland, Ukraine, Romania, Bolivia, Zaire and Sudan.

***Investing in gene banks and gene farming*** is the third key strategy, to preserve the landrace agricultural genes which have developed over the centuries of agriculture. We can't afford to turn the whole Third World into a gene museum. But the world will need better gene storage facilities, and more funding for "gene farms" to keep the genes viable.

What Must We Do Now?

The affluent nations of the world should double their funding for agricultural research. They have the existing agricultural research capacity. There is no possibility that some emerging country could step into the American or Australian research role – in time to save the wildlands.

Countries such as the United States and Australia must also lead the world to free trade in farm products. America has the biggest chunk of prime cropland in the whole world, and is the world's biggest trading nation in both farm and nonfarm products. Australia led the creation of the Cairns Group, long the most important organization in the effort to free farm trade,

Fortunately, when the World Trade Organization reconvenes in late 1999 to take up farm trade reform, the outlook for free farm trade will be much better than in the Uruguay Round. The U.S. will be in the final phase-out of its old price support and cropland diversion programs. The European Union will finally be facing the urgent need to fundamentally reform its Common Agricultural Policy by the accession of Poland, Hungary, and millions of additional low-yield farms to the Union.

The environmental movement deserves enormous credit for setting in motion the whole wildlands conservation effort. However it must now postpone its long-cherished goal of an agriculture free from man-made chemicals, and give up its lingering hope that constraining food production can somehow limit population growth. In the future, we may understand biological processes well enough to get ultra-high

yields from organic farming. Until then, environmentalists must join with the farmers in seeking a research agenda keyed primarily to rapid gains in farm yields whether they are organic or not. Prominent environmentalists have already endorsed a high-yield research drive, including Lester Brown of the Worldwatch Institute, and Jim Downey, executive director of Australia's largest environmental group, the Australian Conservation Foundation. (Brown, 1997, and Avery, 1997b)

Farmers must lay aside their antagonism toward environmental activists. The environmental goals are both valid and urgent in a world that already produces enough food to prevent famine. Farmers must be willing to collaborate constructively and helpfully with environmental concerns in such efforts as protecting stream banks, protecting endangered species, improving water quality and adding an extra lagoon for the hog facility to cut down odor. Without such reasonable efforts, the farmers will not get the public support they need for high yield farming systems and farm exports to Asia. (On the other hand, when major sacrifices for the environment fall on a few farmers, public compensation is in order.)

Government regulators at all levels must realize that chemical fertilizers and pesticides are powerful conservation tools. Internationally, regulators must give up their current fad of "reducing pesticide use by half over the next decade." Given the tendency for pests to develop resistance to humanity's pest control systems (even with IPM) we must encourage the development of new pest control systems with new modes of action -- and keep the widest possible range of pest control systems available. They must stop regarding a pesticide banned as a victory for the environment. They must start thinking globally -- for example, about the environmental impact on three acres of tropical forest if one acre of good American or Australian cropland is shut down for marginal "gains" in the local environment.

Non-governmental organizations, which have become major players in international development and conservation, must accept their responsibility for raising farm productivity even as they strive to preserve the viability of small farmers and ancient seed stocks.

Private companies and their stockholders must aggressively seek opportunities for constructive investments in Third World agricultural research and development. This must include the responsibility to explain the environmental importance of such efforts, and to give developing nations and peoples an appropriate role in decisions, jobs and rewards. Very important in such applied fields as precision farming, conservation tillage, some biotech approaches.

The World Trade Organization and its member nations must recognize that farm subsidies and farm trade barriers have been a growing disaster for the world and for nature. Not only have these national efforts drained hundreds of billions of dollars in scarce capital away from economic growth and job creation, they now represent one of the biggest dangers to preservation of the world's wildlands. The farm trade talks which begin in 1999 must begin the transition to free farm trade as rapidly as possible.

The World Bank deserves major applause for saving the Consultative Group on International Agricultural Research from bankruptcy. Bank Vice President Ismail Serageldin, in particular, has been actively spreading the message that good agriculture helps conserve the environment.

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