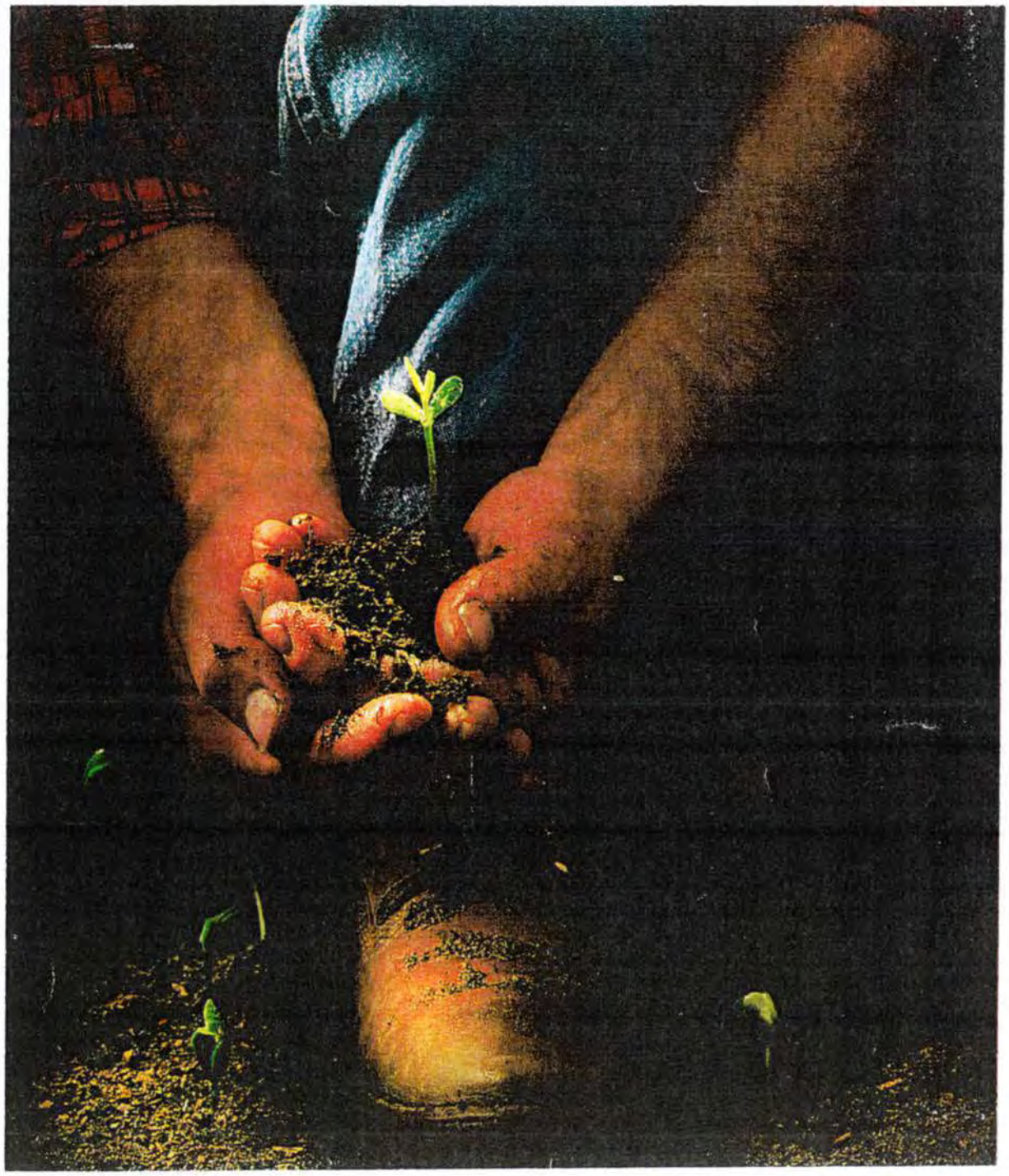

WHEN THE EARTH IS YOUR FACTORY,
YOU LEARN TO TAKE CARE OF THE EQUIPMENT.

THE PARTNERSHIP OF BIODIVERSITY AND HIGH YIELD AGRICULTURAL PRODUCTION

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EXECUTIVE SUMMARY

During the next century there will be a balancing act between feeding billions more people and maintaining our environmental resources. At the current 1.7 percent growth rate, world population is projected to increase from 5.6 billion to 11 billion in just forty years. Growing food needs will increase pressure on global natural resources.

Today we are cropping about six million square miles: approximately the same amount we were cropping in 1950, when the population was half its current level. Therefore, it is estimated that high-yield agriculture is already saving 10 million square miles of wildlife habitat from cultivation. To put this into perspective, 10 million square miles is about 6.5 billion acres, or about 21 times the acreage currently used to produce crops in the United States.

High-yield farming will make additional future contributions to the environment through breeding of better crop varieties, precision farming, and further increased use of conservation tillage. International public policy must encourage production on land best suited for agricultural purposes. These policies will allow the American farmer to play an increasingly vital role as we move into the next century.

World leaders are now assessing environmental issues on a global basis. Largely ignored 10 or 20 years ago, these issues are becoming the subject of important policy today. The first international convention on biodiversity focused the world on the importance and impact of global natural resources. Since fewer than 20 plant species produce 90 percent of the world's food supply, our understanding of the world's biological resources is critical to the future balance and maintenance of our food supply. Conserving and sustaining the earth's natural resources must remain a priority. Agriculture will be a key component of a successful effort to preserve these resources.

Hunger is caused by a number of complex issues -- from politics and logistics to economics and greed. Millions of people, half of them children, go to bed hungry every single day. Some estimates put this number at a billion people. Policies which reduce agricultural production will exacerbate this problem. Therefore, it is critical that the environmental community and the agricultural community work in partnership to apply the benefits of high-production agriculture to benefit the preservation of our natural resources. Neither farmers nor environmentalists can solve all the problems which cause hunger, but it is our ethical and moral responsibility not to become part of the problem. Biodiversity and high-yield agriculture can co-exist and must, if we are to provide adequate food supplies for future generations.

INTRODUCTION

Biodiversity is nature's technology. It is the process by which nature engineers survival and maintains variety. In simple terms, it is the various plants, animals, microorganisms and the ecosystems they compose, as well as the inter-relationships within these habitats. Biodiversity is an environmental treasure, whose endowment is the means of continued life on earth. Biodiversity is the composition of our living resources, and as these resources diminish, our future becomes more precarious. To assure a sustainable future, we must plan to protect the biological components and the habitats which they comprise from unnecessary and irreversible harm. On a human level, biodiversity should be valued much the same as our individual health. People normally refrain from poor diets, consuming items of unknown characteristics, or consciously harming themselves. We make such decisions everyday by determining the risk and long term outcome. Our approach to caring for our natural biological assets should be treated with the same caution, respect and common sense. Our bodies often send us signals when we are not acting properly. Nature sends her own signals when neglected or mistreated. As with our bodies, a certain amount can be endured, yet irresponsible and unchecked behavior will inevitably produce degeneration. Biodiversity is essential for maintaining the quality of human life, and this should be reflected in our actions and our commitment.

It is likely that our discoveries regarding the value of biological diversity will continue for years. It is critical to recognize this diversity as an asset, not a commodity. Assets must be maintained and properly cultivated to yield benefits in the future. We are still discovering the extent of those benefits. Therefore, it is important that this generation use reasonable and sustainable approaches to maintain biodiversity.

Agriculture will play an important role in maintaining biodiversity. Agronomist and Nobel Peace Laureate Norman Borlaug told Congress, "By sustaining adequate levels of output on land already being farmed in environments suitable for agriculture, we restrain and even reverse the drive to open more fragile lands to cultivation."[1] This balance, between feeding an increasing population while maintaining and preserving our biological assets, may be the greatest challenge of the twenty-first century.

The Developing World

The world population is increasing and in the future, societies will demand a higher grade diet as they achieve more affluence. Through high-yield production agriculture the American farmer will provide an essential tool in meeting both these needs. One challenge will be to use efficiently high-yield agriculture to the advantage of biodiversity. This efficient use will help preserve natural habitats such as tropical forests, which are the most diverse and contain an abundance of species. "Tropical moist forests are mostly being lost to agricultural settlement (roughly sixty percent of annual clearing)."[2] These threatened forests are primarily located in developing countries. This is where agricultural development encroaches on these forests, threatening diverse habitats and unique ecosystems. Examples elsewhere in the world can help clarify this relationship.

Last year Indonesia announced it would clear 1.5 million acres of tropical forest to grow soybeans, while nearly 50 million acres of prime farm ground lay idle in the United States. Thailand has deforested 10 million acres for low-yield farming in recent decades.[3] Simultaneously, Ecuador has been expanding its cropland by two percent per year, at the expense of its tropical forest. Ecuador is losing about 136,000 acres of forest per year to keep pace with population growth. (Figure 1) Increased productivity would alleviate the need for this deforestation. Meanwhile, not far from Ecuador, Chile has steadily increased crop yields. Corn yields have tripled since 1950 and have permitted Chile to feed its population while increasing its farm exports by more than 17 percent (in value) per year. Land cleared for crops during recent periods have only increased about 0.1 percent annually.[4]

Figure 1/ Large tracts of tropical forest have been cleared for logging and agricultural use. Once these habitats and ecosystems have been destroyed, they are virtually irreplaceable.

As population expands and diets are improved through better economic conditions, the acreage used for increased food production will be a deciding factor in the well-being of biodiversity. The availability of land is not the only issue. A sustainable food production system will also be an important factor in dealing with greater demand on limited resources. A sustainable food system must maintain environmental integrity and provide the most efficient production with the least impact on our natural resources. This system must also encompass the preservation of natural habitats. There is no greater need for a system of this nature than in the developing world.

Some argue that this goal is not achievable. However, the proper policy and worldwide recognition of established goals such as those in The Convention on Biological Diversity are important pieces to solving this human puzzle. If we proceed on the course currently charted, we will find ourselves without a solution to this puzzle. However, this is not a predetermined course and we can alter it if we choose.

Expansion of agricultural production in countries such as Guatemala, Philippines, Indonesia, Honduras, Costa Rica, Venezuela, Colombia, Ecuador, Peru, Brazil, China, Tanzania and India will continue to threaten plant, animal and microorganism diversity. Many of these countries are also the most likely to plow new crop ground. They are areas where either population expansion will occur or economic prosperity will be slowly achieved. Therefore, unsustainable (or low-yield) farming will continue to consume natural resources and destroy wildlife habitats.

Examples of this threat are easily found. In the Usambara Mountain forests (Tanzania) rapid population growth and the demand for agricultural land continues to encroach on natural habitats. In Central Chile, rural families consume natural vegetation for fuel and livestock fodder, with no replacement policy or strategy. The Uplands of Eastern Amazonia contain the largest flora and fauna of any place on earth. Sixty-five percent of the upland forests have been cleared or converted into palm oil plantations and the prediction is 90 percent by the year 2000. The rain forests along the Atlantic coast of Brazil contain one of the world's most diverse and distinctive biotas in the world. Unfortunately, the forests along Brazil's south Atlantic coast have been cleared to meet the agricultural demands of an expanding population. These are some of the most productive and densely-populated areas in Brazil. In southwestern Ivory Coast, slash-and-burn farming has continued to reduce original vegetation, and what little remains is being cleared. In Madagascar, the impoverished Malagasy people have relied heavily on slash-and-burn agriculture. The cleared rain forests do not provide soils which are conducive to agricultural production, therefore productivity is low. In the Western Ghats of India, pressure from the expanding local populations is intense, and clearing for timber and agriculture has been rapid.[5] These activities cannot continue indefinitely. Increasing yields on local acreage or farming alternative acreage which is more suitable is the only long-term solution that can prevent this destructive behavior.

Unsustainable farming is a large threat to biodiversity. The world's most severe soil erosion is in developing countries trying to support rising populations. This occurs because low-yield farming is extended onto fragile land. Most of the developing world is engaged in the most ecologically damaging part of the economic growth process. Ironically, people's efforts to escape from poverty also damage the environment. For example, timber and cash crops are exploited beyond sustainable levels, and mineral supplies are rapidly depleted in order to earn foreign currency.[6] Developing countries face increasingly serious environmental problems that threaten efforts to improve the standard of living, that worsen health conditions, and that reduce income from agriculture and other sources. In rural areas pressure to grow both more food and cash crops has led to massive losses of topsoil, trees, and native plants and animals.

One of the world's most dramatic erosion and deforestation situations is in Nepal where forests, up to elevations of 2,000m, have totally disappeared. For many years, rice cultivation has been practiced on irrigated terraces on steep terrain -- some over 40 degrees -- to an elevation of 1,500m. But now the soil-holding trees in these regions are disappearing quickly for fuel wood and animal fodder resulting in huge landslides in the

Himalayan foothills during monsoons. These landslides cause the loss of lives, homes and crops. The Nepalese government and UNDP/FAO are carrying out two urgent projects aimed at fighting the problem. One is to integrate watershed management and to control torrents, the other is to bring the population together in community forestry development. The UN involvement reinforces the Forest Ministry's activities which include the education and participation of local communities (panachayats) in planting quickly-maturing fodder and fuel trees, and the building of erosion-control structures. (Figure 2)

Figure 2. A farmer drives his bullock team on a terrace with evidence of dangerous erosion a few meters above him. Landslides pose a constant threat in the region of the Himalayan foothills. Photo FAO, F. Botts.

There is absolutely no question that the Third World is where the future battle for the environment will be won or lost. This is where environmental resources are being depleted most rapidly. This is where the rain forests need to be defended, the urban sewage treated to protect offshore coral reefs, and millions of tropical species identified and protected. As the world triples its demands on farming resources three-fourths of the growth in demand will occur in the densely populated countries of Asia. China has huge tracts of mountains and deserts. Much of India is semi-arid. Bangladesh is waterlogged, and Indonesia is heavily covered with tropical forests. If the densely populated counties of Asia adopt the currently fashionable model of national food self-sufficiency, their environmental losses will be severe.[8] High-yield agriculture, utilizing conservation techniques in areas best suited for cropping, is the only alternative that can minimize this action and eventually eliminate it altogether.

It's not intensive agriculture that is causing environmental degradation in the developing countries, it's the lack of it. In Turkey more than 14 million hectares of farm land have been damaged by severe erosion, and 5 million tons of top soil has been lost annually. Much of this loss is a result of conventional and low yield agricultural practices.[9] Advanced intensive methods of cultivation have dramatically reduced the amount of land, water, soil and energy required to produce a ton of grain -- breaking the link between economic growth and environmental impact. While poverty and a lack of intensive production methods have forced millions of Third World farmers to overgraze marginal

range land or plow up steep hillsides with primitive methods, modern techniques such as "no-till" farming have cut soil erosion rates -- often virtually to zero -- while boosting yields significantly.[10]

The Amazonian rain forest has mostly been felled by projects of little long-term gain such as temporary cattle pastures. Little thought has been given to sustainable use systems for the region. Since less than 10 percent of the total area has been clear-cut to date, there is considerable chance of avoiding the disaster of removing the entire forest. Some signs of a changing attitude towards the value of this forest are given, and suggestions are made about ways to build a sustainable long-term future for the region. These include: the creation of larger conservation areas and indigenous reserves; the adaptation of indigenous agroforestry techniques to use mixed cultures where crops are grown; the restoration with sustainable timber plantations of areas which have already been destroyed; the increase of extractivist reserves and development of markets for products that are extracted from the forest; the greater use of oligarchic forests which are quite abundant in some parts of Amazonia; and the development of agriculture only in the few places where the soils are suitable, such as in the flood plains of white water rivers.[11]

The transfer of global resources will be another key to a successful strategy. This can only be achieved through public policy that recognizes the environmental value of high-yield agriculture. This value, properly applied through economic policies and trade agreements, with allow well-maintained and environmentally low-risk acreage to offset the plow down of forests and wetlands.

Future Demand on Production

To appreciate the magnitude of the U.S. farmer's role in maximizing production to limit deforestation and destruction of fragile lands, it is imperative to think globally. It is incumbent upon us to assess accurately and responsible the world's needs. "Statistics demonstrate that the average daily caloric intake per capita climbed 21 percent from 2,063 calories to 2,495 calories between 1965 and 1990 in the developing countries."[12] Combine this increase in consumption with a population near 10 billion by the year 2050 and the risk/reward relationship in agriculture must be analyzed very carefully. It is important to understand all of the factors involved. A diet currently requires 4,000 gross calories to sustain a diet of 2,500 calories. To maintain this intake level into the year 2050 would require agriculture to increase its output approximately 80 percent. It is also estimated that over 700 million people have inadequate diets which subsequently prevents them from living productive lives. Therefore, to meet this shortfall in Third World diets the demand on agricultural output will be much higher. The decision to expand production will be on a collision course with the environment unless we identify and recognize the value of high-yield agriculture.

We cannot expect people to starve to preserve wildlife. Therefore, if we are to seriously consider feeding the world in the year 2050, we must recognize the fact that high-yield agriculture is compatible with maintaining and preserving wildlife habitat. If we assume growth at recent levels, a simple trend analysis shows that the world will need 100 million tons more wheat in a decade. That is almost twice as much wheat as the United Stated produced in 1994.

Trends indicate the world could require an additional 10 mmt of poultry and 17 mmt of pork annually to supply consumer demand by 2004. This is more than 10 times more poultry and pork than the quantities exported by the United States today. More than 22 mmt of additional soybean meal — the equivalent meal in 1 billion bushels of soybeans — and 120 mmt of additional corn — 60 percent more than the United States produces today — will be needed to produce the meat and poultry the world could require.[13]

A study by Texas A&M University indicates that U.S. field crop yields would decline drastically if we substituted the currently available organic pest controls for synthetic pesticides. Soybean yields would drop by 37 percent, wheat by 38 percent, cotton by 62 percent, rice by 63 percent, peanuts by 78 percent and field corn by 53 percent.[14] Similar cuts in yields would be suffered on farms in other parts of the developed world if organic pest controls were substituted for chemical pesticides. Reduction in crop yields would require plowing down additional acreage to replace the lost production. If the additional land put into crop production has lower productivity, even more plowdown would occur. Dennis Avery of the Hudson Institute projects that if we try to feed the world without chemistry, projecting a human population of 10 billion, we should expect to plowdown another 25-30 million square miles for food production. That would be equivalent to plowing the area of South America, North America, Europe and much of Asia.[15] Proper use of high-yield agriculture can prevent this potential catastrophe to the world's wildlife and our biological resources.

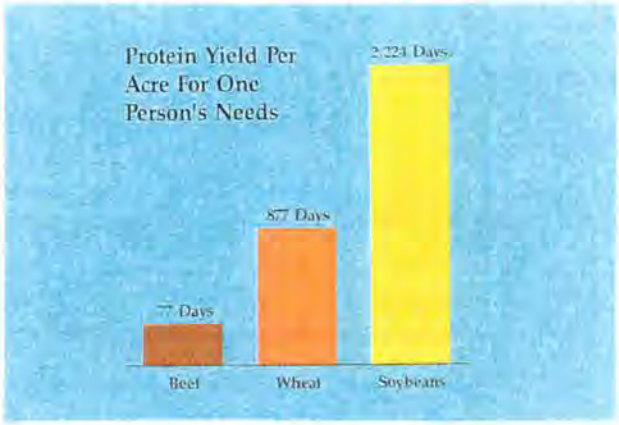


Figure 3. Protein yield per acre for one person's protein needs.

Today a large portion of protein is supplied by beef. At the current 1.7 percent growth rate, world population is projected to increase from 5.6 billion to 11.0 billion in just forty years. To satisfy this expanding protein demand from traditional animal agriculture would require the slaughter of 480 million beef cattle, 2 billion hogs and over 130 billion poultry, compared to the current slaughter of 228 million, 900 million, and 21 billion respectively. More importantly, harvested grain area needed to support these animals would have to increase 70 percent to over 1.2 billion acres. This will be a direct assault on our biological assets. The world does not have the arable land to provide all the additional protein in the form of meat. The next forty years will require an additional 53 million tons of pure protein at current growth rates. Rather than an additional 800 million acres of crops needed to feed the aforementioned animals, the same protein can be delivered from 14 percent of that area or 113 million acres of soybeans at today's current yields. **(Figure 3)** This is one piece of the puzzle, but it will not fit without utilizing effective high production agriculture.

High-yield agriculture has prevented 10 million square miles of land from being cropped. If the population were to double by the year 2050, and yields remained at current levels, another 10 million square miles would be needed to feed population. This may be a conservative estimate. Assuming gains in affluence, improved protein and nutrition demand in developing countries, and recognizing that most all new crop acres can not provide the same yields as prime farm land, new cropped acreage could be even more expansive.

The Role of Technology

U.S. agriculture can contribute to higher production with very limited environmental impact. Since 1950, U.S. agriculture has almost tripled its output. This has been made possible through a number of technological advances. Those who lack foresight and disregard the potential for continued advances in agricultural production fail to recognize the impact of technology. American farmers are the most efficient in the world. They will provide the balance of meeting the increased demand for food while maintaining environmental integrity.

The biggest gains in productivity will continue to come from breeding better crop varieties. For example, hybridization has already boosted corn yields in the U.S. by more than six-fold. Worldwide, the growing season for rice has been shortened from 180 to 110 days, allowing for double and even triple cropping. Researchers believe they can increase rice productivity 60 percent by the early 21st century.[16]

Major advancements in a number of agricultural areas are occurring, from varieties of seed which are designed for specific content yields to matching hybrids with specific herbicides for less herbicide use and improved yields. DuPont has introduced TopCross™ grain, corn grain that contains 50-100% more oil than conventional varieties. High-oil TopCross™ grain provides increased levels of energy, as well as critical proteins and amino acids, resulting in a nutrient dense grain that helps livestock and poultry producers improve the efficiencies of their operations.[17] The results include the more efficient use of resources and providing farmers an opportunity to capture more value from every acre they plant.

Recently, the Environmental Protection Agency (EPA) ruled to allow Monsanto, Ciba-Geigy and Mycogen to grow, but not yet sell potatoes, corn and cotton that are bioengineered to produce an insect killing bacterium called *Bacillus Thuringiensis* (Bt) (see Bioinsecticides). The bacterium kills various beetles, moths and worms, thus reducing or eliminating the need for traditional pesticides.[18] *Bacillus Thuringiensis* is already approved by the EPA for use on various crops, however, this is the first time EPA has allowed the planting of crops bioengineered to produce pesticides. The immediate significance to corn producers will be an insecticide producing hybrid that should eliminate the damage caused by the European cornborer. Using a natural toxin produced by the corn plant itself will reduce or eliminate the application of pesticides and reduce or eliminate the need for synthetic pesticides. This could also lead to a 5 to 10 percent increase in yields.[19]

There are also herbicide-tolerant crops which are being introduced into the market as well as specific herbicides which are matched to specific hybrids. These will result in increased yield potential, and reduce herbicide induced stress. Corn and soybean farmers currently have two legal herbicide-tolerant crops available — IT (imidazolinone-tolerant) or IR (imidazolinone-resistant) corn hybrids and STS soybeans.[21] These

advancements are just now becoming available and it is hard to determine exactly how much benefit and impact they will have. One thing is certain, even limited success could be significant.

New advances for addressing difficult diseases, such as sudden death syndrome (SDS) which has been a problem for soybeans, are also being developed . SDS was identified 25 years ago. There is no effective chemical or cultural control for SDS. According to estimates by Cecil Nickell, University of Illinois soybean breeder and geneticist, there are more than 20 known types of SDS. Each type has the capability to slash yields by 5 to 70 percent as the fungus slowly destroys the plant's roots, vascular tissue and leaves. In 1993, University of Illinois researchers announced they had located a single gene responsible for SDS-tolerance in the soybean variety Ripley.[20]

Scientists may even be able to breed corn so that it can use fertilizer more efficiently. Ammonium fertilizers such as anhydrous ammonia are traditionally the least expensive and most commonly used forms of nitrogen fertilizer. Trouble is, while they start out as mostly ammonium, they don't stay that way.[22]

Too much ammonium scorches leaves and keeps roots from growing, so plants absorb only small amounts of the ammonium. Soil bacteria convert the rest to nitrates. And while nitrates produce good plant growth, they also tend to wash out of fields and into the water supply — something ammonium does not do. "If we could get the plants to take up ammonium instead of nitrates, we think we'd get higher yields from the same amount of applied fertilizer — and we'd reduce environmental contamination," says David Lightfoot, Professor of Biotechnology, Southern Illinois University at Carbondale.[23]

Lightfoot has modified a gene from soil bacteria to make it work in plants. Corn carrying this altered gene would then use ammonium better than present varieties. Any commercial corn product containing the gene is probably 6 to 7 years away, estimates Lightfoot.[24]

"Corn transformed with this gene would allow farmers to get higher yields with the same amount of fertilizer, or, if they are in a watershed area, they may choose to reduce fertilizer and yet maintain current yields," says Lightfoot.[25]

Some of these developments will likely enhance our understanding of biodiversity and how we can apply naturally occurring biological functions for the benefit of commercial applications. An Indiana University biology professor is investigating the genetic engineering of the wild mustard plant which may someday help protect soybeans from bacterial blight disease. The gene in the plant Arabidopsis (native to Northern Europe) could potentially be transplanted into soybeans making them better able to fight off the bacterium that causes the blight.[26] New Mexico State University is researching the potential use of an extract from the neem tree (native to Africa and Asia) as a natural insecticide. Researchers say that the neem tree is unique in that it and related compounds can act as a broad spectrum repellent, anti-feedant growth regulator or toxicant. Whole seed and oil extractions have both systemic and contact activity. It stops insect feeding and has a hormone that halts insect growth. Neem extract controls a variety of pests including beetles, flies, true bugs, scales, lice, mites and nematodes, and it seems to have minimal effects on beneficial organisms.[27] This is where nature and technology merge. It is an opportunity that has just begun to be explored in terms of its benefits to agriculture and the environment. The challenges facing agriculture in terms of providing adequate food for the future may well depend on how well we preserve these opportunities.

The Food and Agriculture Organization of the United Nations (FAO) expects arable area will expand by 12 percent in developing countries while population will expand 47 percent in the same areas. Sixty-six percent of the increased production will come from higher yields, 13 percent from more frequent cropping and 21 percent from expanding area.[28] For instance, corn yields in West Africa currently are a meager 0.8 tons per hectare. Each new mouth to feed means plowing up more land. Simply switching to hybrid seeds and fertilizers. African farmers can boost production nine-fold to 7 tons per hectare. This will help preserve more land in its natural state and protect wildlife habitat.[29]

Per area, farmers do certain things the same for high or low yields. Increasing yields on productive ground to save land for nature will not on a per area basis increase activities like plowing. In fact, per yield, activity done the same for high or low yields will diminish. Per ton, these activities and their fallout will diminish with rising ton/hectare.[30]

The law of diminishing returns demonstrates that greater and greater amounts of a factor must always be applied to achieve ever higher yields. However, we have learned that removing such limitations as deficient phosphate lowers the amount of another factor like nitrogen needed to produce a given yield. Optimizing other factors raises the ceiling that causes diminishing returns and lowers the amount of a limiting factor needed to produce a given yield. Producing the food for 10 billion people will be diminished as land is saved for nature by optimizing all factors to produce more tons/hectare.[31]

High-yield agriculture combined with technology and conservation tillage will provide the means to meet future demand. The U.S. has converted about 25 percent of its cropped acreage to conservation tillage. **(Figure 4)** No-till techniques can reduce water runoff by 92 to 100 percent. New ultra low-rate herbicides will reduce leaching due to rate reductions and accelerated breakdown. These herbicides have favorable toxicological profiles and can be applied at rates as low as one ounce per acre compared to the current 1.5 to 2 pounds per acre. Natural pesticides are becoming cost competitive and have no environmental impact on existing ecosystems. The experimental application of corn gluten, and all natural by-product of corn processing, has shown promise as a weed inhibitor. Precise farming techniques, such as Global Positioning System (GPS), will allow fertilizers and herbicides to be applied much more accurately. We will no longer apply agricultural inputs by the acre, but by the yard. GPS will allow spray equipment to be guided across fields by computers and satellites.

GPS signals allow a computer to scan a yard-by-yard map of the field and assess seven times a second how much fertilizer to apply to each location depending on the soil type, soil acidity, past cropping history, slope, soil hydrology and expected plant population.[32] **(Figure 5)** This will increase efficiency and minimize environmental impact. Combined with no-till farming techniques, these technological advances will enable farmers to conserve and sustain our natural resources. Public policies which encourage conservation techniques are necessary, and simple solutions such as rotation of crops to complicated solutions such as GPS will contribute to this effort.

Today's farming equipment is technology sophisticated. Radar is used to determine exact speeds which then allow the operator to adjust applications of chemical, thus eliminating over application. Some new series tractors offer field cruise. What may sound like a luxury takes the radar sensing one step further. The electronic governing system works like the cruise control in a vehicle. It allows constant speeds, therefore permitting the uniform application of fertilizers and chemicals. The next step will be to

interlink application equipment to this technology eliminating human error and precise application.

Moving from the tractor to the field, research is continuing on using corn dextrose and corn steep liquor as plant biostimulants. These biostimulants are produced from fermentation products and are made from corn substrates, therefore they are "natural" products. Based on current evidence from field trials these biostimulants are low cost and enhance corn productivity. Therefore, they may also reduce the need for nitrogen fertilizer requirements. These biostimulants are well accepted by corn growers because they are very low cost, environmentally acceptable, exhibit high performance characteristics, and may eventually create a demand for 200 mm pounds of corn dextrose and 50 mm pounds of corn steep liquor. Currently the product is being evaluated for its affects on grain yield, kernel yield, kernel size, maturity, plant height, biomass content and pollen shed. It is this type of technology that will continue to provide American farmers with an opportunity to increase yields with no environmental impact.[33]

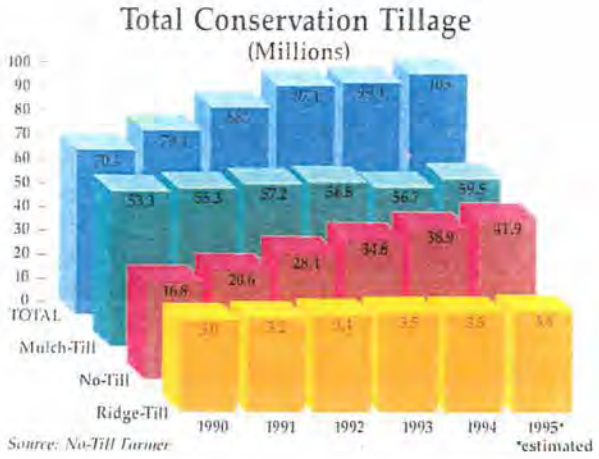


Figure 4. Conservation tillage acres are expected to surpass 100 million in 1995.

Figure 5. Using precise farming technology, application rates are changed on the go. Illini FS, an Urbana, IL cooperative, used the technology on 178,000 acres this year.

The U.S. farmer benefits from other advantages which include infrastructure, capital and management. The productivity of the U.S. farmer is paralleled by the infrastructure provided through distribution, storage, transportation and market access. This is a key point of proper harvesting, handling, distribution and storage. In Armenia, for example, wheat yields range from 3 to 60 bushels per acre in the same field. Harvest loss in the field is calculated to be between 10 and 15 percent compared to 3 percent in the U.S. In addition, an average of over 10 percent of the grain is cracked. At times grain damage was as high as 28 percent. Unfortunately, in areas such as Armenia farmers have been led to believe that a 10-20 percent of grain loss is acceptable.[34] This loss is often times compounded by additional losses occurring when it leaves the field, due to the lack of proper storage and handling. More efficient production in areas suitable to handle and process crops with little waste will reduce the need to cultivate additional acres and make the agricultural system more efficient.

The future for biotechnology is not yet defined and in some sectors remains controversial. New techniques, some of which are hard to imagine today, will contribute to future solutions. Genetically engineered plants will increase the ability of farmers to reduce pesticide, herbicide and fertilizer use. The implementation of these technological advances combined with conservation tillage techniques will be critical to preserving our biodiversity. This concept is illustrated by Paul Waggoner of the Connecticut Agriculture Experiment Station. He calculates that if India's wheat yields had remained at 1960 levels, local farmers would have cleared an additional 42 million hectares (162,000 square miles) to grow the food they supply today.[35] **(Figure 6)** Both Richards in *The Earth As Transformed by Human Action* and Dennis Avery of the Hudson Institute estimate that another 10 million square miles could have been plowed under for crop production if not for high-yield agriculture. Of the world's estimated 3.4 billion hectares of forest, about 1.76 billion hectares or 4.35 billion acres, are tropical forests.[36] To put the 10 million square miles of uncropped acreage into perspective, it would equal 6.5 billion acres, or about 50 percent more than all of the earth's existing tropical forests. This preservation of natural habitat (although impossible to identify how much would be existing tropical forest) would not occur without the technology that has allowed high production agriculture to develop.

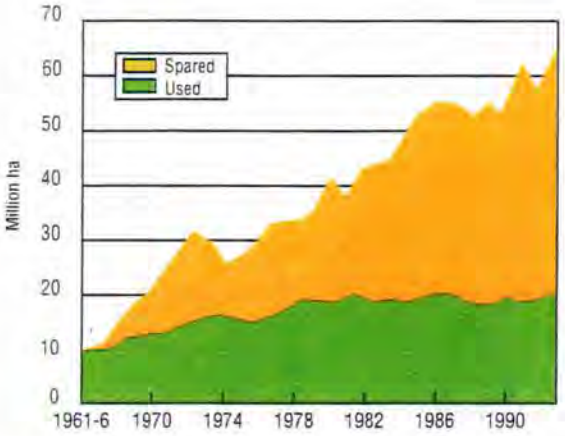


Figure 6. The land that Indian farmers spared by raising wheat yields. The upper curve shows the area that they would have harvested at 1961 - 1966 yields to grow what they produced. The lower curve shows the area that they actually harvested. They spared no difference. Source: Council for Agricultural Science and Technology (CAST).

Today the world crops about 6 million square miles, approximately the same amount cropped in 1950, yet the population has doubled. This ability to feed more people without expanding large areas of crop acres has been achieved with hybrid varieties and increased use of fertilizers and herbicides. Intense farming has been criticized by some, and sometimes those concerns have been valid. However, the negative environmental impact of high-yield farming has often been overstated and misrepresented. Farm pesticides have never been responsible for the extinction or elimination of any species.[37] Farming does not destroy habitats on existing cropped acres. Technological advances and conservation techniques will allow existing habitats to remain undisturbed, deforestation to be slowed and hopefully eliminated and the application of fertilizers and herbicides to be reduced significantly.

Prescription Farming

It is hard to imagine an Iowa farmer using a sophisticated satellite system similar to the one used in the Gulf War. The same technology which guided missiles down elevator shafts and through open doors can be used as precisely in determining the need to vary plant populations and fertilizer applications. Global Positioning Systems (GPS) which can be used for farm applications are a $10 billion network of 24 satellites orbiting 11,000 miles above the earth. Eventually, prescription farming will allow precise

placement of herbicides. Weed pressure zones will be mapped and applicators will adjust applications and rates accordingly. Types of herbicides may even be changed from location to location in the same field. These new herbicides guided by satellite and computer will be able to eradicate individual weeds, foregoing blanket applications of herbicide.

Both co-ops and equipment manufacturers are investing in this new technology. Many crop and fertilizer dealers already offer crop consulting services. Prescription farming will take this service to new heights. Major farm equipment manufacturers are also actively engaged in bringing precise farming techniques to America's farmers. Deere and Company and Case IH have both established Precise Farming Groups. These groups were established to develop integrated farming systems that provide customers with new capabilities to map crop yields and to vary seed, fertilizer and chemical application rates based on specific needs of field locations. The yield monitor package will include a grain flow (and yield) and moisture sensor on the combine, the antenna and receiver to pull in a positioning signal from satellites, a display in the combine, a mapping computer for storage of field information, and the software to allow farmers to develop yield maps on their home computers from data in the yield monitor.[38]

Deere's involvement and commitment goes beyond providing equipment and guidance to their customers. John Deere took another step into the precision farming arena in late 1993, when the company purchased a minority interest in Applications Mapping, Inc.; Top Soil Testing Service Company; and American Laboratory for Environmental Excellence. The three companies have about 50 employees, some of whom are working to tie together a number of the components of the precision farming system — soil testing, crop scouting, field mapping, yield monitors, and farm management software. Precision farming will allow farmers to precisely control the inputs applied to their fields, assisting them in controlling costs. Then, by reviewing site-specific yield results, the actual operating margins for small areas within the whole field can be compared, and better decisions for the next production cycle can be made.[39]

Satellites beam radio waves to GPS receivers, which give instant latitude, longitude, and altitude coordinates. A GPS receiver mounted on a piece of farm machinery allows it to calculate within about 30 feet where that machine is on the earth. A reading of altitude is important for mapping field topology. This information adds to the farmer's knowledge of the moisture retention capability and chemical runoff potential of different fields.[40]

By relaying this information to a computer, it is now practical to map a farm field and divide each field into small grids. **(Figure 7)** Farmers can now log data on everything from soil conditions to weed density into an electronic grid of their field, and use it to place seeds and chemicals in the precise amounts needed to maximize returns.[41]

Soil testing, farming's most basic test, has traditionally required sending a soil sample to a lab. Researchers at the University of Illinois are working on soil sensors that will mount on farm machinery and record fertility, moisture, and other characteristics without ever collecting a bit of dirt. Other "real-time" sensors are being developed to record weed infestations, pesticide and herbicide levels, and even monitor plant health.[42]

The monitor that is expected to truly put precision farming into high gear is one which measures grain yield on the combine while harvesting. It gives instantaneous readings of yield and moisture content on-the-go.[43]

Making this wealth of information useable to the farmer is where expert systems software comes in. Applications Mapping has now released its powerful CropSight software. It allows virtually an unlimited number of layers of information to be recorded for each grid of a field. This means a farmer might be able to consider such data as soil type, fertility levels, fertilizer, herbicide and pesticide records. Yield and production history and projected grain prices can also be analyzed. The software would even allow farmers to "grow" various crops on their farmstead computer and see which practices produce the most profit. Different hybrids, fertilizer rates, plant populations, and row spacings, for instance, could be tried before planting the following spring. One benefit of such intensive record-keeping of all inputs and outputs is that every year, as results are recorded, the farmer's expert system gets "smarter."[44]

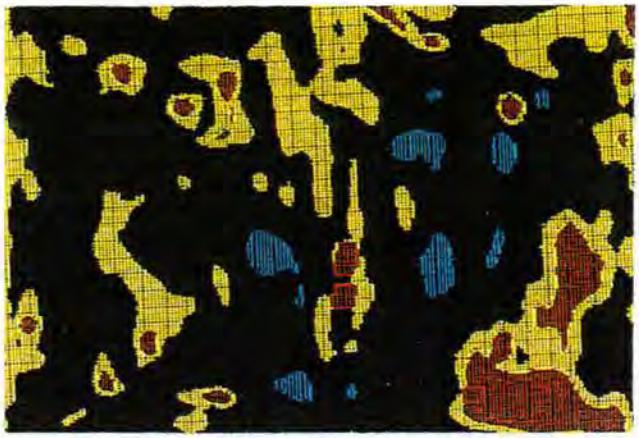


Figure 7. This yield map shows how a field of wheat that looks uniform to the naked eye can vary...from 50 bushels per acre (green) to below 30 (red).

The technology to vary application rates of planters, drill, and fertilizer spreaders is relatively simple and already exists. Ag Chem Equipment Company, a manufacturer of fertilizer application rigs, uses a field map computer disk to automatically control application rates on some of its air spreaders as they cross the field.[45]

As this technology is adapted to more equipment and it becomes more user friendly, the impact on production agriculture will be huge. Prescription farming using GPS may once have been material for Star Trek, but it has become a reality today. To fully understand the impact of these advancements they need to be viewed globally. This technology will provide the means to produce more food while significantly reducing environmental impact on intensely farmed ground. This can translate into preserving natural habitat worldwide and is a piece of the puzzle needed to solve the challenge of preventing primitive, subsistence agricultural practices from encroaching on valuable ecosystems.

Farmers will be driven by economics as much as any other factor to make the investment in prescription farming. Studies conducted by Southwest Missouri State University in Springfield, Missouri over a five year period demonstrated that precise farming techniques increased net return from $7 per acre to as much as $40 per acre.[46] This may be good news for farmers, but the other results from prescription farming may be even better news for the environment.

No-Till and Conservation

No-till can virtually eliminate water runoff. "A Kentucky agronomist reports that no-till fields look like a forest floor or permanent pasture because of nutrient recycling and organic matter accumulation."[47] **(Figure 8)** This contrasts traditional farming methods where soil is completely turned over through moldboard plowing. Plowing leaves the soil exposed to wind and rain, creating a much higher likelihood for erosion. It also disturbs the microorganisms which can build up the tilth and organic matter in the soil. **(Figure 9)** No-till also results in less soil compaction and it provides economic benefits to farmers through reduced capital expenditures and fuel savings. **(Figure 10)** "Farmers report that they are getting more soil nutrients and better tilth because of the decomposing sod and increased activity from earthworms and soil bacteria."[48] **(Figures 11 and 12)** Farmers have also recorded yield increases from no-till farming methods. **(Figures 13 and 14)** In addition, no-till and mulch-till methods can reduce off-site movement of pesticides by as much as 70 percent.[49] With rotation of crops, pesticide use on basic commodity crops can be reduced dramatically. With ultra low-rate application, precision farming, and conservation practices, herbicide and fertilizer leaching will be nearly eliminated. These accomplishments are achieved by focusing production on the highest and best use of acreage.

No-till also offers opportunities to improve air quality. The major air pollutants from production agriculture are dust and CO_2, a greenhouse gas. Most traces of herbicides detected in the atmosphere have been associated with dust particles. Continuous no-till farming will reduce atmosphere dust loading from cropland to near zero. In addition, worldwide adaptation of no-till farming could significantly reduce

Figure 8. No-till farming maintains cover on soil area that would otherwise be exposed. No-till will on average reduce water runoff by 92%, reaching 100% under some conditions.

Figure 9. Moldboard plowing buries the residue from the previous crop, leaving soil exposed with no cover, increasing erosion.

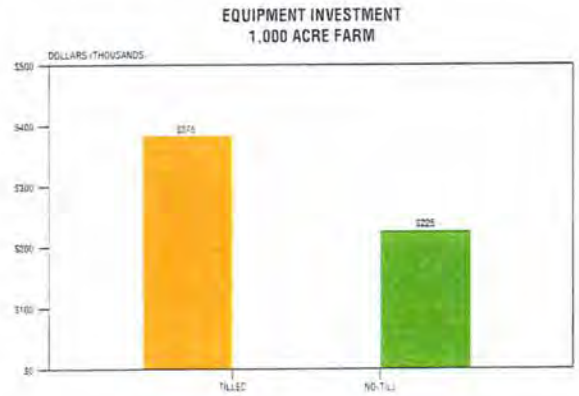


Figure 10. Source: BASF Agronomic Development Center, Jim Kinsella

Figure 11. Source: BASF Agronomic Development Center, Jim Kinsella.

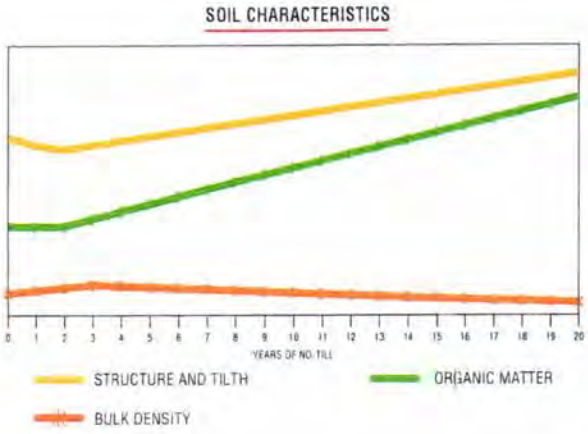


Figure 12. Source: BASF Agronomic Development Center, Jim Kinsella.

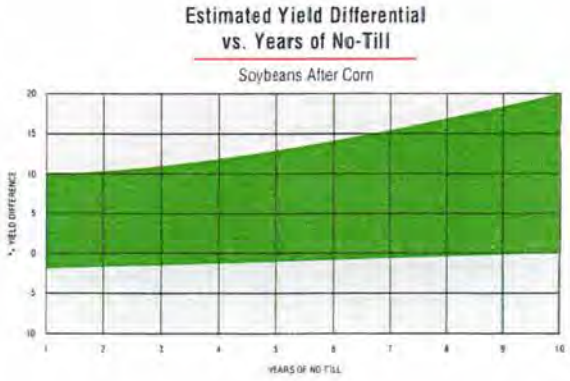


Figure 13. Source: BASF Agronomic Development Center, Jim Kinsella.

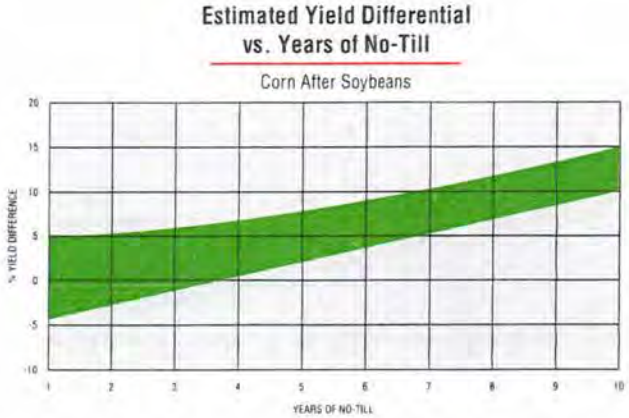


Figure 14. Source: BASF Agronomic Development Center, Jim Kinsella.

the concentration of CO_2 in the atmosphere. Plants take in CO_2 and give off oxygen, retaining the carbon in their tissue. Tillage accelerates the microbial breakdown of the carbon stored in plane residue or soil humus, releasing additional CO_2 back into the atmosphere. In a continuous no-till system, plants take up and deposit more CO_2 than is given off by he oxidation of organic matter and humus. Thus, no-till soils serve as a "carbon sink" much like the soils in the rain forests or native prairies, reducing the CO_2 concentration in the atmosphere.[50]

The United States has also implemented several different management programs to address soil conservation. The 1985 and 1990 Farm Bill legislation requires Conservation Compliance Plans on 143 million acres of highly erodible land (HEL). For farmers to maintain their eligibility for certain U.S. Department of Agriculture (USDA) benefits, the designated farms must have their compliance plans implemented by December 31, 1994. At present, 75 percent of those acres call for the use of Crop Residue Management (CRM), such as mulch-till and no-till. Conservation Compliance legislation will move United States farmers toward effective conservation farming methods. Equipment manufacturers have responded to this by providing equipment suitable for CRM conditions.

Some government agencies as well as private businesses rent no-till drills and other equipment which can be used for CRM systems. All of these initiatives provide more opportunities for farmers to adopt conservation farming methods. Also, innovative programs by groups like the Nature Conservancy provide financial incentives to convert to CRM. An example of the Nature Conservancy involvement is found in the Fish Creek Project.

Fish Creek is perhaps the most biologically-diverse stream system in the Great Lakes basin. It drains a watershed that is almost entirely row crop agriculture. Excessive soil erosion and sediment loading in the stream is cited as the primary stress to the aquatic system and the 31 species of mussels and 43 species of fish that depend on its waters.

Larry Clemens, Fish Creek Project Manager, established a local Advisory Group early in the project to help establish the issues confronting farmers in the watershed and to learn how to address the threat from excessive soil erosion and sedimentation. The decision was made to fund a program incorporating conservation tillage.

The program objective is to promote conservation tillage practices in the watershed by providing financial incentives to farmers who are purchasing their first conservation tillage equipment. Priority areas are croplands adjacent to Fish Creek or primary tributaries and highly-erodible cropland under conventional tillage practices. There are three basic requirements for program participants. First, participants must use the conservation tillage equipment to plant a minimum of 250 acres each year over a three-year period in the Fish Creek watershed. Second, participants must record cost input and yield information to track the economic viability of conservation practices

Farmers Work to Clean Up Union Grove Lake

There was a time when the future of Union Grove Lake looked dim. But times have changed. Or, better said, farmers in the lake's watershed made major changes in their farming practices. Now, soil erosion and nutrient application in the watershed are down and recreational use of the lake is up. Everything from contouring to grass buffer strips to stripcropping to terraces to no-till are now being used in the watershed.

All farmers in the watershed completely implemented their conservation plans by 1993, two years before the deadline set by the 1985 Farm Bill. This was a critical step to protect the lake because more than one-third of the watershed is classified as highly erodible. The 48 landowners and operators in the watershed since 1990 have installed 100,000 feet of terraces, 160 acres of grassed waterways, 30 water sediment control basins, and 80,000 feet of field borders. Erosion potential is now 5 tons or less per acre per year on 100 percent of the watershed's tillable acres. Sediment movement into Union Grove Lake has been reduced by 9,300 tons. Sheet and rill erosion fell from an average of 9 tons per acre per year in 1990 to 3 tons per acre per year in 1993 and gully erosion dropped from 4,500 to 160 tons annually in that time.

A big part of the soil loss decrease is due to crop residue management. Coverage increased from 33 percent in 1990 to 63 percent in 1993. Conservation plans document that no-till is used on an additional 3,500 acres in the watershed compared to 1990.

Larry Pieper farms land in the watershed, some of it within a mile of the lake. He thinks the cooperation shown by both farmers and conservationists has been important. "It took a little time to iron out the wrinkles on what would work on farmland here and what wouldn't." Pieper says, "But after awhile, everybody cooperated. Conservation people will work with you if you will work with them."

Pieper has contour stripcropping and grass field borders, and is 100 percent no-till on his land in the watershed. He is one of many of the farmers following integrated crop management methods, or ICM. Two-thirds of

and report this to the Fish Creek office. Participation in the nationwide, Monsanto-sponsored MAX program (Farming for Maximum Efficiency) qualifies. Third, participants must develop a conservation plan in conjunction with the SCS.

Conservation tillage has a certain momentum of its own within the watershed and beyond, and the Nature Conservancy program is designed to complement it. The Nature Conservancy offers incentive funding for five types of tillage equipment, with minimum usage requirements based on acreage. Currently ten farmers are participating covering 3,000 acres. It is estimated that this participation is keeping an estimated 13,000 tons of soil in place that would have otherwise run off fields and possibly into the stream system. The cost to date is about $14,000. There are three additional farmers who plan to enroll in the program. Their actions will help protect an additional 500 acres. Two of these three are farming in the most critical area of the watershed.

This program has done a number of things for the project: built a higher level of trust, shown a sincere interest in working cooperatively with watershed users, been informative about ag issues and farming attitudes, unleashed the creative ability of farmers, enhanced the level of participation of people from all segments of the watershed, and prepared those involved to explore further similar programs with advances in agricultural technology.

the watershed's producers were introduced to ICM planning through the project and a complete ICM program is used on 45 percent (2,922 acres) of the watershed's cropland. ISU Crop Enterprise Records, which are part of an ICM program, help determine profitability on a field-by-field basis.

Producers in the Union Grove Lake watershed:

* Reduced nitrogen application by an average of 25 lbs. per acres per year — or 42 tons a year overall.
* Decreased phosphorus application an average of 52.5 lbs. per acre per year or 76.5 tons a year overall

The project's ICM program includes weekly crop scouting, which provides valuable information the staff uses to make pest and field management recommendations. Producers then treat crops only when and where pest populations exceed economic threshold levels. For example, one cooperator saved $1,200 on insecticide costs when ICM scouts determined that European cornborer numbers were lower than the economic threshold level. The producer was ready to treat because cornborers were a problem in neighboring fields.

Financial incentives to move toward more sustainable nutrient and pest management programs, conservation tillage, and contour farming have been available to cooperators since 1992 through the ASCS Water Quality Incentive Project. Cost-sharing is also provided through Iowa Department of Agriculture's Publicly Owned Lakes Program and IDNR-administered U.S. Environmental Protection Agency's Clean Lakes Program.

Source: Wallaces Farmer / Our Priceless Soil, Lynn Betts, NRCS Public Affairs Specialist, Des Moines, Iowa

The project has demonstrated that conservation tillage systems, when used properly, are not only better for the soils, but they are proving to be economically competitive with conventional systems, and at some sites even more profitable. These types of local projects can help maintain and restore valuable watersheds and increase yield for local farmers.

However, the impact of soil erosion extends beyond simple yield loss calculations. A study by the U.S. Center for Environmental Assessment Services showed that eroded soils that had a yield 30 percent less than a non-eroded control plot also had a yield that was four times more variable.[51] Therefore, erosion causes direct and measurable losses, but it also affects the future dependability of yields. This complicates any effort to develop a sustainable farming system, particularly in developing countries.

Agriculture will be the key to the world's land use. U.S. farm policy currently idles land through both the Conservation Reserve Program (CRP) and ACR, annually adjusted acreage reduction requirements based on planting intentions. **(Figure 15)** Much of this land could be productive if properly farmed with conservation techniques. Although the amount of permanent crop ground seems small, it is the expansion of permanently cropped acres, nonpermanent acres, and pasture, which threatens natural habitats and ecosystems in some of the most sensitive and marginally productive land in the world. Combining all crop ground and pasture ground, agricultural use accounts for about one-third of the world's land surface. **(Figure 16)** High-yield production agriculture is not zero risk, but the risk is small and getting smaller. The critical point is that the risk to wildlife from modern pesticides and fertilizers is small compared to the risk of habitat loss. This is particularly true if the world attempts to feed its rising population from traditional or organic farming systems. The alternative to high-yield agriculture is to further expand agricultural production into fragile habitats and ecosystems. This alternative is unacceptable.

These conservation efforts are beginning to pay dividends. Soil erosion on cropland from 1982 to 1992 was reduced by one billion tons. This is enough topsoil saved in a year to fill a convoy of dump trucks 100 wide stretching from Los Angeles to New York.52 While this reduction in soil erosion was achieved, farm productivity continued to increase. Farm output of 1990 would have required 734 million acres if produced with 1950 technology. That is 393 million more acres than was harvested in 1991. Considering acreage requirements at the lower yields, cropland erosion could be as much as six times greater today without changes in technology and soil-conservation practices.

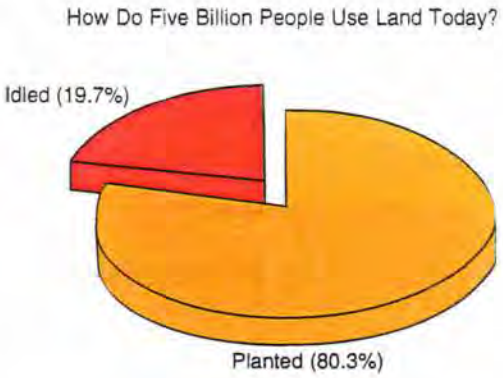


Figure 15. The fraction of U.S. cropland idled by government programs in 1992. The Food and Agricultural Policy 'Research Institute (FAPRI) tabulated the area platned to 15 principal crops in the United States and the area idled by two programs identified by the acronyms ARP/PLD/0-92 and CRP. The idled areas have been or are projected to be about steady 1989-1997, but FAPRI projects them to decline after 1997 (Food and Agricultural Policy Research Institute, 1992,83). Source: Council for Agricultural Science and Technology (CAST).

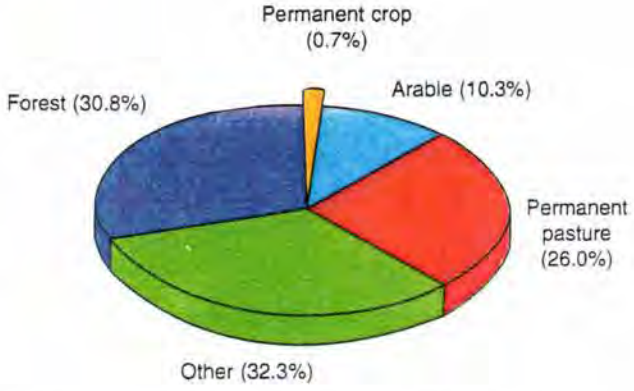


Figure 16. The Food and Agriculture Organization of the United Nations (FAO) (Food and Agriculture Organization of the United Nations, 1992,3) tabulated the uses of the world's 13 billion ha of land in 1990. Source: Council for Agricultural Science and Technology (CAST).

Soil, like many things, can repair itself. Therefore, there is a tolerable level of erosion, although the less the better. Topsoil, using conservation practices, can be replenished if the rate of erosion is limited to approximately 5 tons per acre per year. Five tons represents the loss of a layer of soil that is the thickness of a dime. Ten tons is about the thickness of a nickel, and that is twice as much as agriculture ca tolerate.[53] Soil erosion control does not have to be a zero sum game. Therefore, by improving our farming techniques and by focusing farming on the best suited acreage, we can provide an adequate environment to provide food production on existing cropped acreage.

Irrigation

Although irrigation is impractical in many parts of the world, irrigation techniques are improving. Water management, highly efficient drip irrigation, and automated systems have produced impressive results in recent years. Irrigated acres are not likely to expand significantly or rapidly; however, more efficient water usage is being achieved. Between 1951 and 1990 Israeli farmers reduced the amount of water applied to each hectare of cropland by 36 percent. This allowed the irrigated area to more than triple with only a doubling of irrigation-water use.[54]

Advances in irrigation techniques will be an important factor in water conservation and our food production abilities. The 237 million hectares of irrigated land worldwide account for 26 percent of total cropland and more than one-third of the global harvest. In the U.S., approximately 59 million acres are irrigated.[55]

The two biggest causes of irrigation degradation are preventable. If an irrigation system is designed with adequate drainage, and farmers use only as much water as necessary, an irrigation perimeter can be sustained almost indefinitely. Recent improvements in irrigation technology promise a much higher efficiency in agricultural water use. Farmers are adopting the use of center pivot systems, which are 75 to 80 percent efficient. This is more than double the efficiency of typical flood irrigation. New trailing-tube and drop spray systems can reach efficiencies as high as 95 percent.[56] Other advancements in irrigation have been made. Microsystems operate at low pressure and save energy as well as water; compared to conventional sprinkling, they typically cut the pumping costs in half. Their capacity for applying fertilizer and some pesticides along with irrigation water lessens drift and leaching.[57] New technology has provided an answer to the salinity problem. A new "dual-level" irrigation system developed at Iowa State University not only attains 95 percent water-efficiency, but it also lowers the salinity of irrigated soils and prevents the leaching of farm chemicals into groundwater.[58] As water becomes increasingly valuable, capital becomes more widely available, and as environmental regulations tighten, farmers will move toward highly efficient irrigation technologies.[59]

Seawater irrigation is also demonstrating some success. The terrestrial halophyte, *Salicornia bigelovii Torr.*, was evaluated as an oilseed crop for direct seawater irrigation during six years of field trials in an extreme coastal desert environment. Yields of seed and biomass equaled or exceeded freshwater oilseed crops such as soybean and sunflower. The seed contained 26 to 33 percent oil, 31 percent protein, and was low in fiber and ash (5 to 7 percent). The oil and meal were extracted by normal milling equipment, and the oil was high in linoleic acid (73 to 75 percent) and could replace

soybean oil in chicken diets. The meals had anti-growth factors, attributed to saponins, but could replace soybean meal in chicken diets amended with the saponin antagonist, cholesterol. *Salicornia bigelovii* appears to be a potentially valuable new oilseed crop for subtropical coastal deserts.[60]

These irrigation advances must also be controlled to insure that they do not threaten the natural habitats found in the desert. In appropriate areas this technology may offer a new way to use irrigation. If field experiments are effective under actual production scenarios, the potential for reduced fertilizer use in these plots also exists. Seawater has been effectively passed through a shrimp aquaculture facility, adding nitrogen and other nutrients to the water, thus requiring no supplemental fertilizer.[61] The extent this technology contributes to global food production may or may not be significant in the future. However, it demonstrates the increasing contribution technology can and will make to our future efforts to feed a larger population.

The most likely factor limiting irrigation is from competing uses for limited water resources. Therefore, any significant expansion of irrigated acreage is likely to meet head-on with the need of development competing for the same resources. Western agriculture is facing stiff competition from urbanization and energy development for these limited water supplies. The City of Tucson, for example, is trying to augment its water supplies by purchasing irrigated acreage, thus acquiring the water rights that go with it. So far, according to the U.S. Council on Environmental Quality, the city has purchased about 12,000 acres of farm land, and anticipates that it will need to purchase an additional 36,000 acres by 1985. This will essentially eliminate irrigation agriculture around the city. Similarly, about 50,000 acres of irrigated land around Pueblo and Colorado Springs, Colorado, have been retired in order to meet urban water needs.[62] According to USDA, the annual increase in irrigated land is 700,000 acres per year. Ninety percent of this land is in the 17 western states where major new energy resources are located.[63] The more important issue will not be expanding irrigation as much as converting existing use to more efficient methods to better utilize resources and conserve for the future.

Low-Yield Agriculture

If high-yield agriculture has eliminated the need to plow up 10 million square miles, then it is evident that low-yield agriculture would not be sustainable. Low-yield agriculture would require massive acreage conversion that would devastate our natural resources. Farming systems which depend on natural waste for fertilizer are also not sustainable on a wide scale. There is not enough biomass produced to provide adequate nitrogen and other necessary inputs to support these systems. In addition, the distribution of this biomass would be impossible. The application of biomass or animal manure for fertilizer on a commercial scale is incompatible with most conservation farming methods. Its use with conventional tillage can result in high runoff and uneven distribution. These farming methods can contribute to soil loss, add to water quality problems and substantially reduce productivity.

Organic farming yields can also be low and erratic. Under certain conditions, organic crop yields can be as high as those of chemically supported fields. However, to achieve high yields from organic agriculture the use of large amounts of animal manure is required. This manure must be generated from vast acreages of forage crops, or feed or rotation crops such as clover and oats, which have low cash and nutritional values and low yields. The total productivity of the land currently farmed organically is probably well below half the land productivity generated by more intensive production systems. Therefore, relying on organic farming would mean plowing down millions of square miles of wildlife.[64]

Relying on organic fertilizer would also require more livestock manure than is currently available in the world. Doubling livestock for the extra manure would require farmers to crowd out billions of wild organisms on millions of acres of new pasturage. The world currently has only 10 percent of the manure needed to implement organic farming. Even the U.S., with its rich endowment of land and climate, has only about one-third of the manure needed for organic farming.[65]

Moreover, it is impossible to maintain adequate food production under organic systems in densely populated countries like China and Indonesia. It's unclear what could be done for relatively arid countries such as Kenya where the sparse rainfall can support only the most expansive grazing, making it virtually impossible to collect the grazing animals' manure.[66]

Agriculture: Pesticides and Chemical Use

Farm chemicals were invented to suppress toxins, molds, bacteria and insects that would otherwise infest our food and poison it, or would destroy the food before we could eat it.[67] In many parts of the world microtoxins spoil between 25 and 35 percent of the food before it can be processed or consumed.

Some environmentalists claim that pesticides kill wildlife, but this assumption gets no support from science or logic. Today's farm chemicals do not endanger wildlife. The old broad-gauge, persistent pesticides are no longer in use. They became obsolete because their very persistence caused the pests ingesting them to develop a resistance.[68] The massive pest eradication programs of the 50's against the gypsy moth, the fire ant and the mosquito were humiliating "learning experiences" in our efforts to control nature. Fortunately, the wildlife affected by those programs has recovered.

Modern pesticides target the enzymes of particular weeds or disrupt the reproductive cycle of specific insects — thus having virtually no effect on neighboring species.[69] Today's pesticides have been designed to protect wildlife, and are tested for years before being approved. Newer pesticides use ounces per acre instead of pounds per acre, and disappear from the environment within weeks rather than years or decades. Compounds such as sulfanylureas and glyphosate are so safe we could eat them like table salt, and they don't harm sensitive species like trout and quail. Moreover, it is difficult to get a new pesticide on the market.[70] Federal regulations list more than two hundred sets of tests that a new pesticide must pass.[71] Also, petroleum based and synthetic pesticide and fertilizer use per unit of farm output has fallen in the past ten years.[72]

Pesticide technology is changing and advancing rapidly. A unique new seed treatment insecticide has been approved by the EPA for use on grain sorghum. Gaucho, from Gustafson, Inc., is the first of a new class of insecticide chemistry known as chloronicotinyls. Due to high efficacy and site-specific application, Gaucho can be applied at fractions of an ounce per acre versus the pounds per acre required by soil-applied insecticides. Gaucho is taken up by the roots and distributed throughout the plant as seedlings become established. Since the insecticide is taken up by the plant, Gaucho eliminates surface residues. When Gaucho is applied at the recommended rate of 8fl. oz./cwt. of sorghum seed, it provides early season protection against greenbugs and aphids that typically extends to 80 days after planting, according to the company. In addition, it provides protection against wireworms and chinch bugs during stand establishment. "It represents a completely new mode of action that is extremely effective against a broad spectrum of economically devastating insects," says Bill Hairston, product development manager for Gustafson. "But perhaps more significant is the extremely favorable characteristics relative to the safety of the applicator, consumer and environment." Gaucho has labels pending with the EPA for use with wheat, barley, sugar beets and other crops.[73]

We have also learned that the naturally occurring chemicals in the foods we eat test out as toxic in our rate tests as frequently and as dangerously as synthetic chemicals used in the production of food. Moreover, because we eat much larger amounts of them, these natural chemicals are believed to represent roughly a thousand times greater risk than pesticide residues. The caffeic acid in lettuce, apples, and carrots, the limonene in orange juice, and the hydrazines in mushrooms are all carcinogenic in rat tests. Many other foods contain natural carcinogens.[74] Nevertheless, nutritionists recommend we eat a variety of fruits and vegetables. For example, most of us choose to accept presumably the "non-zero" cancer risk posed by limonene in orange juice to obtain vitamin C. Most people do not find these types of choices to be difficult.

There is no evidence that eating these foods causes cancer. So why should one think that the synthetic chemicals which fail the tests are anything to worry about, especially since they are present in the environment at levels thousands of times below those of the natural ones? The idea that synthetic chemicals are no more noxious than those occurring in nature is not in itself an argument for changing anything. But when tests show that aflatoxin, a toxin made by molds, in the average peanut butter sandwich poses a hazard 75 to 200 times greater than that of ethylene dibromide, a fumigant banned in the early 1980's, then it is fair to ask whether the ban makes sense.

Americans receive 15,000 times as many carcinogens from natural as from synthetic sources. If chemical residues in food were a source of carcinogens, we would expect to see rising stomach and rectal cancer rates resulting from the rise in agricultural chemical use. C. Everett Koop, former U.S. Surgeon General reported in *Progressive* Farmer, "Stomach cancer has dropped more than 75 percent, while rectal cancer has dropped more than 65 percent."[75]

Epidemiology tends to confirm this finding. Richard Peto of the Imperial Cancer Research Fund's Oxford unit has shown that over the past few decades the world's cancer rates have risen, but not because of chemical pollutants. Smoking and increased life expectancy — the incidence of cancer rises with age — are mostly to blame. Ignoring cancer deaths caused by tobacco, the probability of dying from cancer is not increasing in developed countries.[76]

University of California at Berkeley biochemist Bruce Ames calculates that "about 99.99 percent of all pesticides in the human diet are natural pesticides from plants. All plants produce toxins to protect themselves against fungi, insects, and animal predators such as humans." Plants are packed with potent natural rodent carcinogens such as caffeic acid in lettuce and hydrazines in mushrooms. Dr. Ames estimates the average person ingests daily about 1500 milligrams of natural pesticides and just 0.09 milligrams of synthetic pesticide residue. Of the pesticides we consume, just one-ten thousandth are synthetic.

Dr. Ames, who developed the chief method used by laboratories worldwide for detecting carcinogens, estimates that far less than one percent of all human cancers are due to exposure to synthetic chemicals including pesticides and pollution. Toxicologist Robert Scheuplein of the Food and Drug Administration's Center for Food Safety agrees. "Ordinary food contains an abundance of cancer initiators which in total dwarf all of the synthetic sources," writes Dr. Scheuplein in an essay for Global Food Progress 1991 (Hudson Institute). "The total risk from all pesticides and contaminants is a thousand times less than the estimates of cancer risk due to naturally occurring carcinogens."

Consider what is at stake. A 1992 task force on pesticides for the Council for Agricultural Science and Technology (CAST) estimated that "all crop production in the world would decline 30 percent and food costs would increase by 50 percent or more without the use of agriculture pesticides." The need to replace lost yields through expanded agricultural production would affect millions of acres of wildlife habitat.

Environmentalists have to choose between saving the world's biodiversity by forestalling the plow down of wildlife habitat through the continued use of farm chemicals, or protecting society from the minuscule health risk posed by pesticides. The health risks are minuscule.[77]

Regarding pesticides in groundwater, a five-year study of water wells by the EPA reflected only 1.2 percent of urban wells and 2.4 percent of rural wells contained unsafe concentrations of nitrogen. Less than one percent of rural or urban wells contained pesticide residues above standards established by the EPA. Given the margin for error built into safe chemical standards, the survey results suggest that groundwater contamination is manageable problem.[78]

Bioinsecticides

Natural insecticides are beginning to make some headway into commercial markets. One of the most important natural insecticides has been developed from microscopic living organisms called nematodes. Nematodes are natural predators and parasites of many destructive pests. Entomogenous (or insect killing) nematodes are found in soils throughout the world. Under natural conditions, there are not enough nematodes present in the soil to provide adequate control of pests. However, by manufacturing these nematodes in commercial quantities and applying them in concentrated form, they can provide highly effective and economical "natural" control.

Entomogenous nematodes are harmless to plants, humans, animals, birds earthworms and beneficial predators. These nematodes carry a symbiotic bacterium which kills the insect via septicemia. This bacterium is released into the bloodstream of a host insect when the nematode enters it in search of a breeding site. The nematode kills the host pest within 24-48 hours. After breeding, the nematode's progeny leaves to seek additional hosts.[79] **(Figure 17)**

Why beneficial nematodes?

1. Seek and Kill. Unlike nearly all other bioinsecticides (even Bt products), nematode-based insecticides do not rely on passive contact or ingestion. They actively seek out and kill their prey.

2. No Resistance. INsect populations are not likely to develop a resistance to septicemia. Septicemia is the biological reaction that causes death from a general infection to multiple systems within the insect. As opposed to this, resistance can develop to other toxins or Bt products.

3. Environmentally Sound. Beneficial nemotodes do not contaminate the environment. After application to the soil, they biodegrade once the target insect population is controlled. Also, they cannot survive at mammalian body temperatures and have proven harmless to humans, pets, livestock, earthworms, and plants.

4. Broad Spectrum. Nematodes can by used to control a broad range of soil-inhabiting insects and above-ground insects in their soil-inhabiting stage of life. More than 200 species of inscet pests from 100 insect families are susceptible to these nematodes.

5. Flexible Tool. Nematodes can by used with several other classes of insecticides, fertilizers, and herbicides as part of an integrated pest-management program.

6. EPA Exemption. Perhaps most important, given the regulatory environment, nematodes are currently exempt from registration in the U.S. and several European countries because of their benign nature.

Figure 17.

Source: Biosys 1993 Annual Report

Another new nematode species being developed for commercial application is *S. riobravis*. Isolated by scientists at the U.S. Department of Agriculture, *S. riobravis* is particularly effective where soil moisture levels are low — the conditions in which corn, cotton, and soybeans grow. *S. riobravis* attacks corn earworm, a pest that costs U.S. growers an estimated $1.5 billion a year in insecticides and yield losses. This new nematode species is also effective against pests of cotton, turf, citrus and vegetables, including tobacco budworm, cotton bollworm, fall armyworm, citrus weevils and mole crickets.[80]

Nematodes were developed through molecular biology, microbial genetics, biochemistry and bioengineering. This same technology is now leading to the development of bioinsecticides based on a naturally occurring virus called baculovirus — a safe and effective biological pesticide for control of foliar insects. One important strain of baculovirus is known as the celery looper virus. This strain will not be the first baculovirus used in viral insecticides, but it offers several significant advantages over its predecessors. This baculovirus can be used to control a broad range of economically important lepidopterous pests. Insects are not expected to develop resistance to the chemical pesticides or products using the bacteria-produced biotoxin *Bacillus thuringiensis* (Bt). This particular strain of baculovirus has shown greater stability after field application than other viral strains.[81]

Most bioinsecticides today are formulations of Bacillus thuringiensis, products that rely on bacteria-produced biotoxins and are used primarily to control above-ground pests.[82] After more than 20 years of development and testing, bioinsecticides are beginning to offer realistic alternatives to synthetic chemical pesticides.

Sustaining Agricultural Production

An additional concern is that of agricultural sustainability. The earth's natural systems currently support an estimated 5 to 50 million species,[83] of which humans are only one. Yet humans either use or displace about 40 percent of the earth's total photosynthetic output — the source of all food.[84] If the human population increases another 50 percent by the year 2020, as projected,[85] more than half of the world's land-based food resources will be needed for human use.[86]

Since 1961 food production has kept pace with population growth in all developing regions except sub-Saharan Africa.[87] However, the FAO projects that more than half of developing countries (62 of 115 studied) may not be able to feed their projected populations from their own land by the year 2000 using current low yield farming techniques. Most of these 62 countries may be able to feed less than half of their projected populations from their own land.[88] World-wide, the average amount of cropland per person is projected to decline from 0.28 hectares per capita in 1990 to 0.17 hectares by the year 2025.[89] More advanced farming techniques will be needed in the future to offset projected population increases.[90]

Over the past decade and a half, the United States has cut back its harvested area of grains and oilseeds by some 16 million hectares (40 million acres) while less developed countries (LDC) of the world have increased their area by 35 million hectares (85 million acres). Much of this increase in LDC is a result of little or no increase in crop yields. The two charts below[91] demonstrate that increased harvested acres by LDC have not managed to keep pace with U.S. agricultural efficiency.

HARVESTED AREA OF ALL GRAINS & OILSEEDS
(Million Hectares)

Region	1980	1994	Change
Less Developed Countries	370	405	+35
United States	105	89	-16

YIELD OF ALL GRAINS & OILSEEDS
(Kilograms per hectare)

Region	1980	1994	Change
Less Developed Countries	1.22	1.55	+0.33
United States	3.05	4.50	+1.45

Much of the farm land in LDC is considered by U.S. standards as "low-yielding" or "marginal." The crop yields in LDC are less than one half of those in the U.S. due to inadequate application of fertilizers and other chemicals.[92]

The low yields, and the failure of yield growth to keep pace with population and incomes, drives LDC to plant more land. Almost all of this additional land is even more "marginal" than what is already in place, and much of this additional land is "environmentally fragile."[93]

Thus, whether intended or not, the fact is that each year high-yielding land in the United States is set aside and low-yielding, fragile land elsewhere on the planet is put into production.[94] This land put into production in the LDC is highly susceptible to soil erosion, and soil erosion is the single greatest threat to sustaining food production.

High-yield agriculture radically cuts soil erosion. Doubling the yields on the best and safest acre cuts erosion per ton of output at least in half. In addition, high plant populations produce a heavier crop canopy sooner, thus conserving moisture and reducing weed germination. Today, we are cutting soil erosion by 65 to 98 percent due to the use of high-yield farming in North America and Europe. The herbicide-based farming systems are the most sustainable farming systems ever devised. They save more soil than any other farming system. Conservation tillage coupled with high-yield farming encourages more earthworms, more soil microbes and more soil tilth than plowing. When conservation tillage is combined with high yields, the soil erosion per ton of farm output should be less than one-third of that suffered on organic or traditional low-yield farms.[95]

Higher yields require little more work than low yields. The land requires little or no additional clearing, tilling or cultivating for high yields than for low ones. Also, labor, capital and fuel costs are reduced on a per unit basis with high yields. Because herbicides account for more than half of all pesticides, knowing that bumper crops require less herbicide is reassuring. The dense shade provided by bumper crops reduces the number of weeds that sprout as well as limits the growth of the few that do. Furthermore, luxuriant foliage protects the soil from erosion better than does sparse foliage.[96] Therefore, intense farming provides advantages over low-yield production.

To preserve our biologically diverse habitats, there must be policies which encourage and regulate the development of a global strategy. These policies need to include trade agreements which encourage the exchange of goods based on an overall examination of environmental impact and risk assessment. Without these policies, high-yield farming will be unable to significantly contribute to the preservation of wildlife habitats. This confirms the importance of policies and agreements such as the treaty proposed by The Convention on Biological Diversity.

Deforestation

The torching of the Amazonian rain forests was the dominant environmental image of the 1980's — towering trees backlit by fires ignited to create new rangeland for cattle and sheep. During the decade, 70 million hectares of Latin America's forests were logged or burnt; another 70 million hectares were lost in Africa and Asia. Yet, amidst the smoke some different numbers emerged. In Europe, the former Soviet Union, Canada and the United States the rate of deforestation began to reverse itself. Almost 22 million hectares of forest plantations were established worldwide.[97]

Left to its own devices, the earth would be a forested planet. Currently less than a quarter of the world's original forest remains, most destroyed during the past 50 years. Every week another 400,000 hectares disappear, and the rate of destruction has doubled over the past decade.[98]

The consequences of losing the world's forests are serious. The rain forests are essential to regulating the world's climate. They cleanse the atmosphere and provide a source of moisture for rainfall.[99] Forests serve many other essential ecological functions, including soil retention and water absorption, which help to prevent floods, landslides, and erosion. For example, Ghana lost nearly one-third of its closed (dense) forests between 1937-38 and 1980.[100] Much of the wood goes for household cooking. Nine of every 10 African household burn wood for cooking.[101] The World Bank estimates about two million hectares (five million acres) of tropical forest vanish in Africa every year. Since 1975 Ivory Coast has been losing its forest faster than any other country in the world, leaving it with only a tenth of its original forested area.[102]

Of the 76 countries that now have tropical forests, only four — Brazil, Guyana, Papua New Guinea, and Zaire — may have large stands of undamaged forest remaining by the year 2010. Tropical forests are vanishing at an estimated rate of 17 million hectares annually — an area roughly the size of Kampuchea, Tunisia, or Uruguay and larger than England and Wales. Asia is losing its forests fastest, at a rate of 1.2% annually, while Latin America is losing 0.9% annually, and Africa, 0.8%.[103] Latin America is rich in natural resources — for example, it has more forests than any other developing region.[104] More than 8.3 million hectares of Latin American tropical forests are cleared annually for agriculture and settlements. This accounts for almost half the world's total forest loss. Brazil alone lost 1.4 million hectares of forest in 1989-90.[105] Some 90 percent of its Atlantic Coast forests have already vanished.[106]

Forest Facts

Ratio of area deforested: area planted
North America: **1.1:1**
Asia: **2:1**
South America: **6:1**

Annual per capita consumption of paper and cardboard
in North America: **690 lb**
In Asia: **20 lb**
In Africa: **12 lb**

Percentage of annual domestic timber harvest used for fuel and heat:
Japan: **1.1%** US: **17.7**
Italy: **48%** Sudan: **91%**
Bangladesh: **97%**

Number of people worldwide dependent on firewood for cooking their food:
2 billion

Value of developing countries' timber exports in 1989:
US$13.4 billion

Estimated annual value of plant-based drugs produced worldwide:
$43 billion

People in India employed by forest-based businesses:
30 million

Disposable wooden chopsticks used annually in Japan:
25 billion

Source: FAO, World Resources Institute, Worldwatch

Studies in Cote D'Ivoire show that deforested hills lose 500 times as much topsoil in a year as those with trees. In all, 26 billion tons of soil are blown or washed away worldwide each year, largely as a result of deforestation. Over the last 20 years the world has lost as much soil as covers the U.S.[107]

It is often presumed that because of its luxuriant growth, rain forest must lie over a rich soil. Quite the contrary is the case for most of the Amazon rain forest, which covers areas of extremely poor soil with low nutrient content. Some of the Amazon forest is over sandy soil that contain virtually no nutrients. The available nutrients are in the vegetation rather than in the soil, and they are rapidly recycled as leaves and branches drop to the forest floor. It is common to see roots of living trees growing upwards in search of nutrients into dead trunks and tree-stumps. If the forest is cut and burned, then most of the nutrients are washed away into the streams by the heavy rainfall. Streams in undisturbed rain forests are of pure, almost distilled water, but streams in deforested areas are full of the escaping nutrients that are vital to sustaining the forest or even a crop. The clay latosols and sandy soils of Amazonia do not have the colloidal properties to retain nutrients. The ecology of the region points towards species-diverse forest as the best land cover, and plans for its use and development should be geared towards maintenance of the forest cover.[108]

Land covered with trees and other plants also absorb 20 times more rainwater than bare earth. Their leaves break up the impact of the raindrops, and their roots allow water to precolate into the ground. Without tree cover, floods become more frequent and groundwater supplies dry up. Almost 60 million hectares of land in India is vulnerable to flooding, twice the area threatened 30 years ago. Yet the number of villages short of water in the state of Uttar Pradesh, where there has been heavy logging, has more than trebled in the past 20 years. Two-fifths of the world's people depend on the forest cover of mountain ranges for stable water supplies.[109]

Indiscriminate logging is a factor in our changing climate. Forests regulate the climate, generating rainfall and absorbing carbon dioxide, the main cause of global warming. Felling trees accounts a fifth of the world's emissions of carbon dioxide.[110]

The great majority of the earth's plant and animal species depend on forests: tropical forests alone harbor half of them in only 6 percent of the planet's land surface. As the trees are felled, the rate of extinctions accelerate to an estimated 10,000 times the natural rate, threatening a biological holocaust akin to that which swept away the dinosaurs 65 million years ago. Ominously, the diversity of plant life — which survived earlier mass extinctions — has been the first to suffer.[111]

For all these reasons and more, study after study shows that forests are far more valuable standing than clear cut. One such study, in the Cameroon, showed that preserving its Karup rainforest — which protects a valuable watershed — will provide benefits 25 times greater than those gained from destroying it. Another study in the Peruvian Amazon concluded that sustainably harvesting the forest for fruit and latex (natural rubber) was nine times more valuable than felling it for timber.[112]

Yet the trees keep falling. Over 30 percent of the world's original forests have been razed, and another 45 percent fundamentally altered by human activity. Only a quarter remains intact.[113]

The fate of the tropical forests became a cause celebre in developed countries — half of those forests have been felled this century, and if current trends continue no large expanses will exist by 2025. But these developed countries have an even worse record. The temperate rainforest of Northwest America, one of the most productive ecosystems on earth, is being cut down even faster than its tropical counterparts.[114]

Worldwide, only one hectare of tropical forest is planted for every 10 cut down. In Africa, the ratio is closer to 1:30. Most temperate forests are replanted, and in some rich countries the tree cover is increasing. But while it is much better to replant than not, the new forests bear little relation to the ones they replace. Complex old forests are replaced by regimented stands of, at best, a few species — planted, in the words of one Canadian forester, "as thick as bristles on a bear's back". They have none of the ecological richness of the original forests, and they are not as good at safeguarding soil and water.[115]

Biodiversity and the Future

Biodiversity has the potential to contribute to greater agricultural yields. Therefore, destruction of biological assets could limit the contribution of high-yield farming in the future, by limiting future discoveries and uses of natural applications to agriculture. Fewer than 20 plant species produce 90 percent of the world's food supply. Limiting our options in diversity could be suicidal, particularly if we do this while concurrently adding to the uniformity of genetic strains. Biodiversity holds great promise for applications in agriculture.

Biological diversity — a composite of genetic information, species, and ecosystems — provides material wealth in the form of food, fiber, medicine, and inputs into industrial processes. It supplies the raw material that may assist human communities to adapt to future and unforeseen environmental stresses.[116]

Forests are not just a source of timber; they contribute to a wide range of social and ecological functions. They provide a livelihood and cultural integrity for forest dwellers and a habitat for a wealth of plants and animals. They protect and enrich soils, provide natural regulation of the hydrologic cycle, affect local and regional climate through evaporation, influence watershed flows of surface and groundwater, and help to stabilize the global climate by sequestering carbon as they grow.[117]

The potential benefits to agriculture from biodiversity can be illustrated by the neem tree. Chemicals extracted from the neem tree have been patented as a natural insecticide.[118] The potential for insect-resistant hybrid strains will depend on our understanding of the interrelationships of various organisms within their natural habitat. Therefore, the destruction of this habitat may eliminate our opportunity to understand how to utilize these natural resources to our advantage. Biodiversity may hold the key to the eventual elimination of petroleum based pesticides, yet the value of maintaining biodiversity goes well beyond the potential for agriculture.

One-third of all pharmaceutical drugs come from plants. Yet only ten percent of the world's plants have been tested for their medicinal value.[119] The plant species Maytenus buchananni is the source of the anti-cancer compound maytansine.[120] Extract from Aloe Vera plant has been used successfully for general medicinal purposes. Cells from the spleen and liver of the armadillo were used to develop an anti-leprosy vaccine, thus virtually wiping out leprosy world-wide. Rosy Periwinkle, found on the island of Madagascar, provides the substances Vinblastine and Vincristine. Since the introduction of theses two drugs, childhood leukemia survival rates have increased 10-90 percent. Scientists estimate that there are at least ten more "miracle" drugs like the Rosy Periwinkle on the island of Madagascar alone. A wild form of corn was discovered in the Cloud Forest of Jalisco, Mexico. When crossed with domestic corn, the hybrid was more

resistant to disease. This hybrid has helped feed millions and has brought a nice profit to the $60 billion corn industry. A barley plant form Ethiopia was found to have a gene that now protects the $160 million barley crop in California. The saliva from a South and Central American vampire bat was found to open clogged arteries twice as fast as conventional medicine. These compounds are now being developed to help prevent heart attacks. Salicylic acid discovered in the Meadowsweet plant is the chief active ingredient found in common aspirin.[121] Ancistrocladus Korupensis is found in a small region of tropical forest and contains a substance with the potential to fight the AIDS virus.[122] A heat resistant enzyme in the bacterium Thermus aquaticus can be cultured and used to identify throat bacteria in a matter of hours. This microorganism was discovered in the scalding waters of a Yellowstone Park hot spring. Taxol, a molecule powerful in the treatment of breast cancer, was isolated from the bark of the Pacific yew — and evergreen recently considered a trash tree in Northwest logging operations.[123] Newly discovered enzymes are being developed to decompose waste. Cyclosporine, an immune-suppressive substance from a fungus, made the entire industry of organ transplants possible.[124]

Americans purchase $8 billion worth of pharmaceutical products that were developed directly from the rain forest. That's 42 percent of all pharmaceutical products. So while Washington talks health care, the rain forest delivers it.[125]

Approximately 119 pure chemical substances extracted from higher plants are used in medicine throughout the world. At least 46 of these drugs have never been used in the United States. Among these 199 drugs, 74 percent have the same or related use as the plants form which they were derived.[126] While 1.4 million species have been identified, the estimated number of species has been anywhere between 10 and 100 million.[127] These unidentified species are potential sources for new pharmaceuticals, improved crops, fibers, petroleum based product substitutes and agents for restoring soil and water resources. **(Figure 18)**

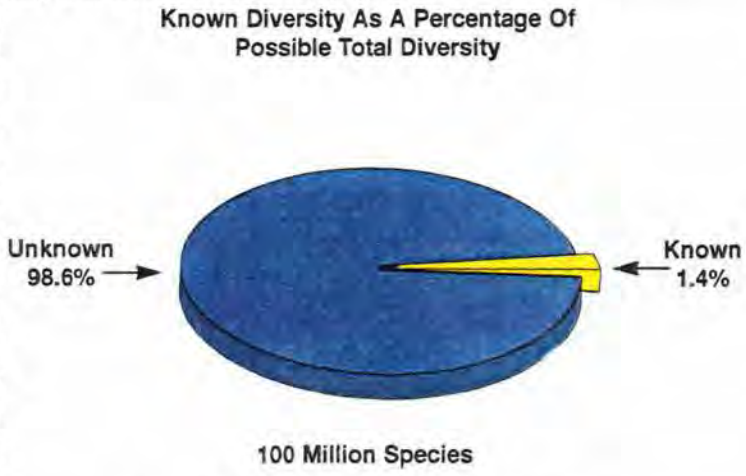


Figure 18. This chart demonstrates the extent of mankind's knowledge of the possible total species diversity on earth.

Tropical forests contain more than half the species of plants and animals on earth.[128] An estimated 50 percent of all the world's species inhabit about 6 percent of the world that is rain forest. It is estimated that Costa Rica alone possesses 5 to 7 percent of the world's species. Western medicine has managed to study closely only 1 percent of the world's 250,000 higher plants.[129] To date, half of the world's original rain forests have been destroyed. When these forests are destroyed, a wealth of plant species disappears forever.[130] **(Figure 19)** A variety of changes can force species into

decline. However, physical destruction of natural habitat accounts for almost 75 percent of the extinction or endangering of existing species. The main cause of deforestation continues to be small scale farming, especially slash-and-burn cultivations that lead to permanent agriculture settlement.[131]

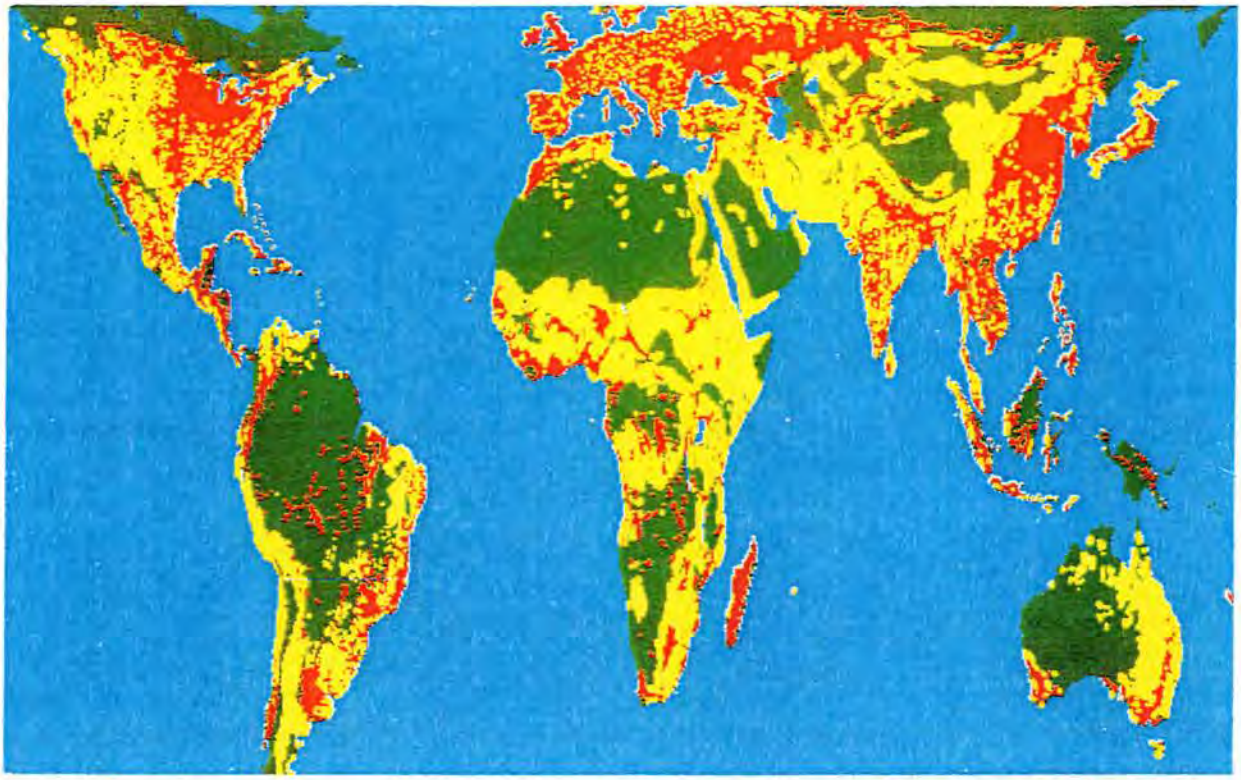


Figure 19. Source: Conservation International.

In the Amazon region by far the largest cause of forest destruction has been the creation of pasture for cattle. Since most of the region has extremely poor soils, the pastures are not viable in the long term and have a life of only a few years. Cattle pasture was only made viable by tax incentives and land speculation. There are some ranches that have never sold cattle to the market. The rest sustain one cow or less per hectare. The fact that these pastures were created by government incentives also means that it is relatively easy to end destruction by removing the tax breaks. This has happened and today there are no longer any tax incentives for cattle pasture in Amazonian Brazil.[132]

However, considerable areas of forest were destroyed during the time of fiscal incentives. Rain forests with a huge biomass and with great biological diversity (anything from 87 to 300 tree species per hectare[133]) were replaced by a grass monoculture to support cows for 3 to 8 years. There was a great acceleration of deforestation in 1987[134] as landowners sensed the coming of the restrictions and an end to tax incentives, and so they felled large areas to claim their title to the land. Subsequently deforestation decreased in 1988 and 1989[135] and the government of Brazil has used the military to patrol and stop the cutting and burning of the forest.[136]

The uniqueness of tropical forests provides an immense understanding of nature's

interdependent relationships are either disturbed or destroyed. Consequently, the entire ecosystem is disrupted and our understanding of it is further limited. The value of these forests' diversity is better understood by examining a specific example.

In a sample hectare of rain forest in Chacobo Territory, it was found that the Indians use 82 percent of the species (75 of the 91 tree species) and an amazing 95 percent of the individual trees in the forest (619 of the 649). These uses include all categories such as medicines, building materials, fuel, ornaments, paints, fibers, etc.[137]

The Amazon plant species that are presently used by several Indian groups are minimal in comparison to the possibilities. Commercial interest in some useful plants has already developed. These plants include: palms pupunha (*Bactris gasipaes*) and babassu (*Orbignya sp.*), the moraceous tree mapati (*Pourouma cecropiifolia*), and the edible species of Calathea (*Marantaceae-batata aria*). There is more flora which could eventually be used such as cupa (*Cissus gongyloides in the Vitaceae*). It is the carbohydrate source for the Indians in the southern part of the State Pará. Bekú (*Curarea tecunarum in the Menispermaceae*), is the contraceptive of the Deni Indians and there are 26 species of edible fungi consumed by the Yanomamo.[138]

Many of the plants which we already use have their related species in the forest. It is essential to preserve them. With modern genetic engineering their importance increases as it becomes easier to genetically transfer disease resistance and other beneficial characteristics (such as higher protein content) from wild species into cultivated ones. Thus the more than 20 wild species of *Theobrama* are important to the future of cacao and the 10 wild species of *Hevea* are important for further development of rubber. These are the species that are threatened by the destruction of the forest.[139] This is just a sampling of the opportunities tropical forests provide. These opportunities need to be protected.

Property Rights and Communal Ownership

In the U.S., some agricultural groups originally opposed ratification of The Convention on Biological Diversity. However, the American Soybean Association and the American Farm Bureau Federation later withdrew their objections. Organizations such as the American Seed Trade Association, Inc., American Corn Growers Association, the Farmers Union and National Cooperative Business Association supported ratification of the treaty. One agricultural organization opposed the treaty due to concerns over property rights. This is ironic, because the most successful approach to protection of natural resources in the developing world will be through strong property rights laws. Communal ownership has contributed to the serve loss and degradation of our natural resources. Agriculture, under communal operation has been inefficient, abusive, and devastating to the environment. Political and social conflict is also more likely without property rights laws. Lack of property rights encourages irresponsible behavior. Private ownership provides the owner incentive to maintain and preserve the resources which can provide profit or value. Loss of value to a property owner represents a personal loss; loss of value to communal property can go virtually unrecognized. Some of the world's most important natural resources are located where individual property rights are scarce or abused. Corruption or lack of enforcement in these areas allows for the abuse to continue.

"Assignment" of property rights by governments has usually failed. A few make the decisions for many, and the few normally profit from the decisions. A recent example in Brazil highlights the problem. "Since their reserve was consolidated in the past few years, the chiefs of almost all of the 20 or so Kayapo villages have been cutting illegal deals with loggers and miners. The contracts have brought money, gold, and all matter of gadgets to the chiefs — but have wreaked mostly misery on the 4,000 Kayapo tribe members."[140]

Governments have a moral responsibility to protect natural resources. Yet in today's world, without global collaboration and cooperation government protection will fall short of most reasonable expectations. Public policies will drive the effectiveness of these efforts. Part of this policy needs to incorporate agriculture's contribution by focusing production in specific areas most suitable for raising corps. A system of property rights will be essential to encourage the maintenance of existing resources.

One approach in the Amazon has had some success. The "extractive reserve" approach in the Amazon basin is an attempt to keep forests intact and provide an economic base for inhabitants. This is done by setting aside areas for the careful harvesting of products such as rubber, nuts and fruit. Elsewhere in the Amazon, and in Brazil's Atlantic forest, some paper pulp enterprises are attempting to balance environmental protection and economic growth by setting their Eucalyptus plantations in a matrix of natural forest.[141] These approaches and others must incorporate orderly development and preservation of natural resources and provide an economic advantage to the local people.

The results from failing to protect common property are not as acute as the failure to maintain private property. The investment by a private owner motivates development of sustainable and reasonable practices. A farmer who owns his land pays taxes, invests in improvements and counts on the property for future income will behave differently than a roving individual who will deplete a resource of no personal long-term value. One farmer is likely to develop a strategy of productivity and efficiency, while the other will typically slash-and-burn and abandon the property. One key to protecting natural habitats and fragile ecosystems is ownership; property rights provide a strong incentive to protect property. The concern that government infringement on private property rights in this country may go too far is a valid concern. There is no greater awareness of infringement on private property rights than in the agricultural community.

There are a number of examples where environmentalists have clashed with farmers over property rights, "taking issues" and protection of specific plants or animals. Part of the debate involves the confusion created by ambiguous laws and enforcement responsibilities which cross several different federal agencies. Cases exist where authority granted at the local level is later challenged or overruled at the federal level.

Using eminent domain or zoning laws as guidance, the government must have reasonable cause for its "taking" action and provide fair compensation for condemnation and possession of property. If an action diminishes the use or value of property it is usually assumed that there will be fair compensation for the loss. Action which leaves property with no economically viable use is unacceptable. The impact to the private owner has the same consequences.

The Power of Politics

"I have seen fortunes made overnight from the forest and it makes my skin crawl to realize that there are many Filipinos who just don't care about the future generations' legacy in the way of forest resources."

This quote sounds like it came from an unyielding environmentalist. But this is from no other than the former Philippine strongman Ferdinand Marcos, the leader who presided over massive deforestation in the Philippines - and his words described exactly what happened during his term. Marcos said this in 1978 and, in his typical doublespeak, absolved himself of the crime of plunder. But in reality, for the 20 years from 1965 to 1985, he used his power to grant and revoke logging concessions to enrich himself, his family and friends. The forest became his political tool.

As a result of his actions, deforestation peaked in the 1960s at 300,000 hectares a year driven by the growing number of concessionaires, a thriving export market for logs and increases in the population. By 1991, only 6.46 million hectares of the original 27.5 million hectares of virgin forest were left.

The Philippines is still recovering from the legacy of the Marcos years. When Coraxon Aquino was swept in as president by popular uprising in 1986, she made natural resource protection one of the hallmarks of her administration. She stopped the granting of licensee to loggers, trimmed the number of forest concessionaires and the amount they were allowed to cut, banned logging in virgin forests and engaged in widespread reforestation.

Licensed loggers declined from 143 in 1987 to a low of 32 in 1992. A number of politicians were rebuffed, their concessions closed down for reasons ranging from overcutting to logging outside their concession. The deforestation rate was 80,000 to 88,000 hectares a year from 1988 to 1991.

The Aquino government also started to address the issues of equity and who has access to

One of the most visible and controversial programs affecting the use and value of private property has been the regulation of our nation's wetlands under Section 404 of the Clean Water Act. This program illustrates the potential conflict between conserving natural resources and protecting private property. It is particularly constrained due to both the breadth of the program and the fact that more than 70 percent of this country's wetlands is located on private property. When development activities on private lands are restricted by the U.S. Army Corps of Engineers because they might result in an unacceptable impact on wetlands, the livelihood of all landowners if affected. These landowners effectively are being asked to surrender the use of their land to the public good, a burden that should be borne by the public as a whole. Try to imagine what the reaction would be if the federal government told citizens when (or if) they could cut their grass, or water it, of where they could put their garden.[142]

The challenge the nation faces is how to achieve our environmental and natural resource goals in the context of preserving our political, constitutional and economic structure. Congress must understand the impact of regulatory programs on private property and either prevent the involuntary "taking" of private property by the government or provide appropriate compensation to the landowner if the property is taken.[143]

One highly publicized case provides an excellent example of this conflict. Charles Gunn of Jefferson, Iowa, had lost the right to farm 28.2 acres of previously farmed wetlands where drainage was "improved" by a new ditch installed by his drainage district. This prime farm land was tiled in the early 1900's. It virtually always produced a crop.[144]

Gunn's only role in the matter was to pay a $25,000 assessment to his drainage district. The Natural Resources Conservation Service (NRCS) — formerly the Soil Conservation Service — had no objections to the work, says drainage district trustee Royal Holz II, because the land drained by the 21/2-mile ditch had been classified as "prior

the forests - basic issues in determining who would protect the forests.

Today, President Fidel Ramos has made it a high priority for the Presidential Anit-Crime Commission, headed by Vice-President Joseph Estrads, to go after illegal loggers. A high-profile crackdown - arrests and confiscation of illegally cut timber were made with full media coverage.

Ramos continues to place environmental protection on his short list of priorities. He took over where Aquino left off expanding a program wherein communities living in forested areas are organized into cooperatives and are then assigned as guardians of the forests.

This program is based on the belief that communities are in the best position to manage and protect the surrounding forests. "This program is a way of democratizing access to forest resources and alleviating poverty, while, at the same time, protecting the remaining forests," says Ben Malayang, Department of Environment and Natural Resources (DENR) under-secretary.

NGOs and the military, have been set up in some parts of the country, particularly in critical watersheds. They supervise the formation of forest cooperatives. The DENR provides money for seeds and works to develop alternative sources of income for the community until it can harvest some of the timber in its management area. The DENR reports that the deforestation rate in 1993 was under 80,000 hectrares per year.

Despite snags, many in the DENR, NGOs and the upland communities want the program to work. New solutions unavoidably clash with old habits and spur resistance from comfortable, entrenched interests. Communities, at the same time, need to understand the program better value this change. The results will take a long time to come, but the seeds are being planted now.

Source: The WorldPaper, Feb. 1995, Filipinos Win Access To Trees by Marites Danguilan-Vitug

converted cropland." That is, all wetland characteristics had vanished before the 1985 farm act took effect. The only exception was some farmed wetland that NRCS had identified on Gunn's land. The land had been tiled since 1908.[145]

"There is a 28 inch main and lateral under those farmed wetlands," says Gunn. Drainage was such that "I would lose an acre or two of crop from standing water if we got a heavy rain. Maybe two years out of 10, I would lose 20 acres." Gunn agreed to give up some land so the ditch could be built. "I understood that a few acres would become converted wetland," he says. "NRCS told me that [the drainage effects] might extend out 105' from the center of the ditch."[146]

But after the ditch was completed in 1992, NRCS found it drained farmed wetlands farther out in the field. When Gunn planted in 1994, the converted wetland areas were pegged at 17.2 acres. During his final appeal hearing, officials adjusted the converted acreage to a total 28.2 acres, in two spots.[147]

Gunn figures he lost about $5,000 by not growing soybeans on the 17.2 acres last year. (Beans elsewhere in the field made 55 bu. per acre.) In 1995, he will lose more because the acreage increased and he planned on planting corn. Taxes at $16.22 per acre will remain the same whether the land is cropped or not, Gunn notes. "It's pretty discouraging," he concludes.[148]

Ironically, Gunn's track record indicates he would be the last person to intentionally harm to the environment. After purchasing 20 acres in the 1980's, he took 31/2 acres of sandy soil out of production and planted 3,500 trees at his own expense. "I saw so many trees going down, and I wanted to do my part [for the environment]," he says. "But [in the farmed wetlands case] I don't like having my farm ground taken away."[149]

Only some legal technicalities kept Gunn's problem from becoming even worse. If he had dug the ditch, merely draining the farmed wetlands would have triggered Swampbuster penalties. (With drainage districts the trigger is the planting of a crop.) If the ditch had been constructed after August 1993, Gunn would have violated the Clean Water Act, as well.[150]

Gunn is not the only farmer sacrificing income because of farmed wetland rules. In Murray County, Minnesota, farmers have spent $10,000 trying to obtain permission to enlarge a tile outlet. Farmers on prior converted land higher up in the watershed can continue to install tile, tile farther down blows out and farmed wetlands get wetter. Natural Resources Conservation Service (NRCS) official say enlarging the outlet will improve drainage if those farmed wetlands beyond what it was in 1983.[151]

NRCS is starting to certify all existing wetland determinations or issue new ones. Even if land is currently designated a non-wetland area prior to being converted, regulations require recertification periodically. Land could revert to farmed wetland status if drainage is not maintained.[152]

Cooperation Yields Environmental Dividends

The Herington Lake project is a prime example of the success of cost-sharing rather than the use of fines. In 1991, the Kansas Department of Health and Environment (KDHE) identified Herington Lake as the most polluted city water supply in the state. As a result, the Dickinson County Conservation District developed an NPS pollution plan for the 15, 853 acre watershed. After state approval in 1992, funding began to trickle in from the Kansas Water Plan budget, through its Conservation Commission, to farmers.

The project targeted 12 beef producers whose feedlots needed to be relocated away from the banks of Cress and Lyon creeks. Cost-share assistance of 70% was offered. Now, only two years into the five-year project, creek water samples show levels of phosphates, chloride salts and organic matter have fallen by 83%. (Figure 20)

Ammonia, nitrates and fecal coliform bacteria levels also declined sharply since 1991, as shown in the table below. Initial testing showed bacteria counts as high as 80,000 per 100 ml of water, 40 times the tolerance level. By 1993, the average count was 1,446, though some samples still spiked above 6,000.

Water-quality officials didn't expect to see results so soon. After all, the trend toward pollution of the central Kansas watershed had been established for more than 100 years, and producers had begun to change their ways in only the past few years.

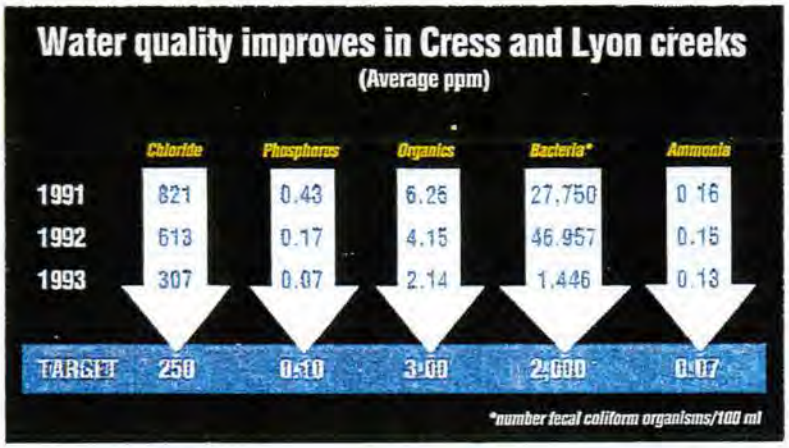
Even some of the producers who have relocated are amazed at the dramatic declines. Mike Beltz, Ramona, Kansas, first realized his 300-head feedlot's creekside location was history when he saw a KDHE agent walking through it in 1992.

"Isolation used to be our major comfort, but obviously that wasn't working any long," says Beltz. "We hated to move the lot, because the protection was so good – we never even know when the wind was blowing," he says of the lot that now grows soybeans and milo. "But that's progress. We can't leave a mess for the next generation."

"Our programs appeal to the polluters' moral sense," says Kansas NPS pollution chief Don Snethen. "Most people will take responsibility for their actions, if they aren't resource-limited."

Source: Farm Journal, Jan. 95, Toward High Ground, Steve Suther

Some farmers are objecting to the new determination process. Farmed wetlands are most likely to be found in areas such as the prairie pothole region where much land is drained by shallow tile laid in the early 1900s. "It doesn't seem fair that people could improve their drainage to modern standards until 1985, but those who didn't have the financial resources at that time now are locked out," says Kossuth County, Iowa, supervisor Lennon Brandt.[153]



SOURCE: KDHE

Figure 20. Two years into a five-year project, creek water samples show dramatic improvement. In fact, all but one of the target goals have been met–and exceeded.

However, despite a number of concerns over these issues, there are success stories. A project called "Seeking Common Ground" (SCG) is proving that ranchers and environmentalists can work together. On the ag side, the effort is supported by the National Cattlemen's Association and Farm Bureau. Federal and state government agencies and two wildlife-oriented foundations.[154]

SCG forms coalitions of ranchers and environmentalists to improve public and private rangeland for cattle, big game and recreation. "We've had excellent participation at the local level," says Farm Bureau's Herb Manig.[155]

Nine demonstration projects are in place in Arizona, Colorado, Montana, Nevada, Oregon, Utah and Wyoming. "The fact that we're about to make our third grant to the project shows that we believe Seeking Common Ground is working," says Amos Eno of The National Fish and Wildlife Foundation. "We have no desire to regulate or acquire every piece of important wildlife habitat. We think farmers and ranchers are key to the equation for wildlife."[156]

Providing a balanced system which encourages private ownership and fair compensation for government intervention is imperative to a successful effort to create an orderly system of property rights. Disagreements in the United States should not prevent our participation in the convention on Biological Diversity. To the contrary, the U.S. can provide important leadership for the development of property rights policies. Through our participation in The Convention on Biological Diversity the U.S. can provide this leadership. These policies can play an important role in protecting biodiversity worldwide.

Central American Efforts Toward Sustainability

The following text is reprinted from the
Keynote Address by the President of Costa Rica
José María Figueres Olsen
at the Central American Environmental Summit
Managua, Nicaragua

Since the 1980's Central America has been confronting an environmental crisis that – if not reverted – could constrain opportunities for future generations. To avert disaster, the Central American countries have embarked upon unprecedented efforts to preserve their environment while developing economic opportunities, institutional capability, and political stability. Some of the major initiatives include:

Institutional

- In 1989, at the Summit of Costa del Sol, El Salvador, the Central American Presidents agreed to create the Central American Commission on Environment and Development (CCAD). CCAD works to protect the region's great biological and ecosystem diversity, facilitate the regional adoption of sustainable development lifestyles at all levels, and coordinate environmental education and training, watershed and ecosystem protection, tropical forest preservation, urban pollution control, and toxic substance management. Its members are elected by their governments and are usually Ministers of the environment and natural resources. In 1992, CCAD coordinated the development of a joint position statement (Central American Agenda for Development and Environment) for the region at UNCED. Since then, CCAD has been instrumental in many initiatives that encourage sustainability, such as the creation of the Central American Inter-Parliamentary Commission on the Environment.

Forest Management

- To address deforestation, CCAD created a forestry unit to come up with a regional Tropical Forestry Action Program (TFAP) for 1990-91. Among the guidelines for forestry concessions since adopted by governments are the commitment to establish forest policy based on zoning, the adoption of a contractual system for the long-term use of forests, and the even-handed application of laws regulating forestry activities for national and foreign concessionaires.
- The Convention for the Management and Conservation of Natural Forest Ecosystems and the Development of Forest Plantations, signed by the region's governments, proposes a framework for revising regional forestry codes. The goal is to consolidate systems of protected areas, reforest and rehabilitate degraded lands, and concentrate management activities and forest production in secondary forest areas. By securing pledges in these areas, the convention will develop respect for the rights of groups that live off the forests (such as indigenous peoples), strengthen intersectoral coordination, promote capacity-building, and create a legal framework to assess the

impact of various activities on forests. Upon the ratification of the convention in 1993, the Central American Council on Forests was created to bring together the region's national forest service directors and TFAP coordinators with the regional network of farmer's unions, forest industries, and women's groups.

- The forestry codes of Guatemala and Nicaragua were revised in 1993 and 1994 to incorporate recommendations from public forums on forest-concession policy. In Nicaragua, an intersectoral consultative body of the national forestry administration review all proposals for forest concessions sent to government for approval. Similarly, in Guatemala, national forestry administrations, concessionaires, and local communities together help establish pilot projects to test the revised forest-concession policy and decision-making procedures.
- Many non-governmental organizations (NGOs) are collaborating with community-based groups on reforestation, tree nurseries, agroforestry schemes, and seedling distribution. In 1988, in one relatively dry pine forest area in San Jose de Cusmapa, Nicaragua, the community addressed deforestation and drought problems through consultative project planning with a predominately female cooperative that managed some 1,440 hectares of forests. In other initiatives, 910 acres of pine forest are being managed, charcoal production ovens are being built, technical training and assistance are being provided to local communities, and public awareness of women's integration into forest management is being raised. Over the past five years, the Regional Consultative Council of Women and Forestry in Central America has held two workshops to study how to replicate the Cusmapa experience — especially with regard to female leadership and gender issue in forestry.

Biodiversity Conservation

- In June 1992, Central America's Presidents signed the Central American Convention on Biodiversity. The Signatories recognized that this convention would serve as a useful regional mechanism to protect and conserve natural areas for aesthetic, historical, and scientific reasons. Since then they have been working to identify new, and strengthen existing protected areas; to develop national strategies to preserve such areas; and to establish, as an adjunct to the CCAD, the Central American Council on Protected Areas. In addition, the International Convention on Biological Diversity has been ratified by Belize, Costa Rica, and El Salvador and signed by Guatemala, Honduras, Nicaragua, and Panama.
- Biodiversity prospecting – the exploitation of genes, plants, and animals for commercially valuable resources – was introduced as a viable alternative to tropical forest harvesting through an accord between Costa Rica's National Biodiversity Institute (INBio), a non-profit organization, and Merck & Co., Ltd., the U.S.-based pharmaceutical firm. Since 1991, INBio has been providing Merck with Chemical extracts from wild plants, insects, and lands for Merck's drug-screening program. In return, Merck gave INBio $1,130,000 for a two-year research-and-sampling budget and royalties on any resulting commercial products. INBio is using the funds to help support a Costa Rican biodiversity inventory, which will help generate further income to maintain the country's ecosystems.

• Biosphere reserves are being set up throughout Central America. They protect core, transition, and buffer zones by imposing strict controls on resource extraction, and emphasize securing higher yields in the transition and buffer zones without jeopardizing the integrity of the core area. La Amistad Conservation and Development Initiative aims to conserve a 2.7-million acre reserve on the Costa Rica-Panama border. This joint effort brings together conservation expertise, scientific and educational knowledge, and corporate know-how to find viable rural development alternatives within buffer zone communities in the reserve. A similar effort in the Rio Bravo Conservation and Management Area in Belize by the Nature Conservancy, the Program for Belize, USAID, the Massachusetts Audubon Society, and Coca Cola Foods encourages local *chicle* harvesting for international chewing gum manufacturers so as to avoid intensive natural resource extraction in this buffer zone.

• A cross-ministerial and government-NGO commission is currently helping convert up to 2 million of Costa Rica's 2.5 million ha of pasture back to woody crops and forest. Last November, the Ministry of Natural Resources, Energy and Mines, along with the Ministry of Rural Development, inaugurated the 7,000-ha Horizontes Forest Experiment Station of the Guanacaste Conservation Area — an enormous field trial and center for research on native woody plants. Using the station as a research base, teams of government and private extension agents advise government on how to switch from grass to woody crops and how to launch forest-restoration projects. A National System of Conservation Areas is also being created. Key to this operation are decentralized management, a restructured National Park Foundation, higher entrance fees to Conservation Areas, and the re-training of Conservation Areas staff in local biodiversity management and ecosystem maintenance.

Sustainable Agriculture

• In the Maya Biosphere Reserve in Guatemala's Petén department, Conservation International, the Guatemala National Council for Protected Areas, and local communities are promoting alternatives to slash-and-burn agriculture, cattle ranching, and destructive logging. In about half the reserve area, only scientific investigation, eco-tourism, and education are permitted. The remaining area and the 15-kilometer square surrounding the buffer zone are devoted to local sustainable economic activities and sustainable-management project work. Protetén, as this effort is called, is run by local Guatemalans. To become self-sufficient, it is using a debt-for-nature swap that generated $1.33 million to form a permanent endowment to fund long-term conservation.

• In Zamorano, Honduras, the International Food Policy Research Institute, the Escuela Agricola Panamericana, and the International Development Research Center of Canada have joined forces to develop a methodology for participatory research on sustainable hillside agriculture. They will map community resources to indicate whether maintenance has improved the hillsides, as well as how policies affect their condition. Through this educational process, the project helps build local expertise and increases the community's capacity for political negotiation.

Climate Change

- The Central American Convention on Climate Change was signed in 1993 in Guatemala by the Central American Presidents. They, in turn, set up a council on climate change that oversees national and regional policies and programs geared toward climate change reduction. Additionally, the International Framework Convention on Climate Change has been ratified by Belize and Costa Rica and has been signed by El Salvador, Guatemala, Honduras, Nicaragua, and Panama.
- In Costa Rica, new regulations govern the use of fuels and control CO_2 emissions. As of 1995, electric power and oil companies must submit proposals (such as plans to reforest degraded watersheds) to compensate for their operations' harmful environmental effects. It is expected that by the year 2000, some 98 percent of electric power will be generated by hydroelectric plants, wind, and geothermal energy.

Education and Training

- Throughout the region, many countries have produced national environmental education plans. Honduras, Costa Rica, and Panama have pioneered these efforts. The Honduran Ministry of Public Education's Environmental Education Unite, now known as the Department of Environmental Education and Health, released plans for a national strategy in 1992. In Costa Rica, the Department of Academic Education and an advisory unit, in conjunction with the National Ecology Program, ensure that environmental education is incorporated into the curriculum at all levels. In Panama, a national environmental education strategy formulated in 1992 calls on various ministries, educational institutions, and NGOs to coordinate their work on environmental education curricula. In addition, the National Association for the Conservation of Nature established a pilot program on environmental education for students and educators at rural schools, which has encouraged the PA.NA.MA. Foundation to run a parallel program in urban schools.
- NGOs continue to play a critical role in environmental education in Central America. In Guatemala, for example, they have been working closely with the Ministry of Education to train environmental educators and prepared support materials. Through the comprehensive Basic education Program, they disseminate material on natural resources and the environment and produce an environmental education magazine that is circulated to over 2,000 educators and students. Furthermore, the Association for Social Research studies has provided 2,500 teachers and students in northern Guatemala with environmental educatino support materials; Friends of the Americas has produced a teachers' manual in the Petén department; and the Centavo Foundation provides teacher training. Similar efforts in Nicaragua are also noteworthy: one example is the work of the Nicaraguan Environmental Conservation Foundation, which is establishing ecology brigades in thirty secondary schools in Managua and ten institutions outside the city.

Collaboration in capacity building enables institutions to help low-income people become self-sufficient through management training and technical and credit assistance. The Katalysis North-South Development project provides these services to self-help organizations in Belize, Honduras, and Guatemala, and helps indigenous groups, women, small-scale farmers, and small-business owners develop micro-enterprises, manage

natural resources, and establish women's community banking. The Belize Enterprise for Sustained Technology, for instance, extends services to more than 11,000 community members involved in women's banking and small fishing and farming cooperatives. The Cooperative Association for Western Rural Development in Guatemala, an all-Mayan organization, provides technical assistance, training, and credit to more than 6,000 people. And in Honduras, the Organization for Women's Enterprise has helped women in 60 communities get more than 2,000 small business off the ground since 1985.

- Cooperation among local government and civil society has improved environmental management in several countries. The two-year old *Coordinadora Regional Ambiental*, for example, coordinated the environmental activities of government agencies, NGOs, and grassroots organizations in Northeast Guatemala. By capitalizing on their complementary strengths and avoiding duplication of efforts, they define and apply a regional environmental education strategy, establish a regional network of environmental NGOs, coordinate and support environmental research in universities and research centers, and organize environmental promotion and extension activities in biosphere reserves.

The Role of Government

- In 1994, the Costa Rican National Sustainable Development System (SINADES) was set up to coordinate sustainable development programs in that country and to ensure full public participation. With representatives from different sectors of civil society and state agencies, SINADES will monitor compliance with international commitments and the application of policies and programs designed to develop sustainable social, economic, and environmental conditions. Members include the National Council on Sustainable Development; the technical Advisory Commission; and the Sustainable Development Area Board.

Civil Society Involvement

- Civil society has been taking an active role in the innovative financing of environmental activities. The Protected Areas Conservation Trust, a National Environmental Fund in Belize involving government, NGOs, and the business sector, collects and $8-per-tourist tax that is channeled into a trust fund that also receives money from site-entry fees, recreation licenses, and permit and concession charges.

The Business Sector

- NGOs have been working with businesses to develop environmentally friendly business practices. The ECO-O.K. Certification Program of the Rainforest Alliance endorses tropical agricultural products that are grown with minimum adverse environmental impacts. Examples include banana projects with Costa Rica's Fundación Ambio and Ecuador's Corporación de Conservación y Desarrollo, and the ECO-O.K. coffee project — a joint effort in Guatemala with Rainforest Alliance, the Interamerican Foundation for Tropical Research, and the Central American Coffee Company. The ECO-

O.K. standards have been negotiated by environmentalists, industry, government representatives, and researchers. Rather than imposing standards on industry from the outside, the sponsors of the ECO-O.K. projects work directly with industry and the program is carried out by an independent and credible third party.

- The Biodiversity Management Information System (BIMS) grew out of a business partnership between Costa Rica's National Biodiversity Institute (INBio) and Intergraph Corporation — the world's largest manufacturer of interactive computer graphic systems. Under a contract signed in November 1992, Intergraph provided $750,000 in hardware, software, development, and maintenance, and INBio provided expertise in system design and on-site software development. The BIMS system will convert large volumes of data on species into useful information in an accessible format for users from diverse technical and non-technical backgrounds. This agreement, the first of its kind, enables INBio to develop a biodiversity management system that accommodates its ten-year inventory of Costa Rica's biodiversity and permits Intergraph to replicate the system for other consumers.

International Linkages

- On September 30, 1994, Costa Rica's President Figueres and U.S. Vice President Al Gore signed an agreement on "Joint Implementation" projects — cooperative ventures that mitigate the effects of global climate change by reducing or storing greenhouse gas emissions. The linchpins of these projects are education and training programs; increased diversification and training programs; increased diversification of energy sources; conservation, restoration, and enhancement of forestrial carbon sinks; the market deployment of technologies that reduce greenhouse gases; and information exchange on sustainable forestry and energy technologies. This agreement enables Costa Rica to better monitor water loss and contamination, soil and air pollution, biodiversity loss, and unsustainable land-use practices.
- At the Ecological Summit in Managua and the International Conference on Peace and Development in Tegucigalpa in 1994, the Central American leaders invited the international community to help them achieve the goals of the Alliance. Accepting this invitation, the U.S. Government signed an official agreement with the Central American Presidents on December 10, 1994 called the Conjunta CentroAmerica-USA. The agreement calls for all parities to jointly support the promotion of clean and efficient energy use; the identification, conservation, and sustainable use of the region's biodiversity; the strengthening of institutional and legal frameworks and compliance mechanisms; and the improvement and harmonization of environmental protection standards.
- The Global Environment Facility has proposed establishing a Central American Environmental Conservation and Management Fund to further cooperation in environmental conservation and management. The Fund would expedite project processing and disbursements and make confessional loans. Its Management Board would consist of representatives of recipient governments, civil society, the private sector, bilateral donors, and other funding institutions. Monies would finance projects that promote national priority actions that enhance regional and global sustainable

environmental management — among them, work on capacity building, the sustainable use and conservation of environmental resources, alternative energy efficiency, regional biodiversity and ecosystem networks, the cessation of land degradation, and improved watershed management.

Future Initiatives

- The Costa Rican government hopes to create a National Fund for Sustainable Development (FNDS) to better internalize the costs and benefits of sustainability. The Fund could be financed by "environmental certificates" that would enable international groups to invest in those sustainable development projects that best reflect their concerns and needs. Proposals for the certificates include swapping debt for carbon storage, facilitating participation in scientific research on biodiversity, and stocking carbon in Costa Rica's forests. The government also plans to develop titles for carbon sequestration that will give the bearer the right to claim a certain amount of carbon storage in Costa Rica that it has paid for, thus offsetting its emissions elsewhere. The title will be offered to the public in fixed amounts, probably through secondary markets and a commodity exchange.

Text: Central American Efforts Toward Sustainability[157]

Cropping Alternatives

Adapting crop varieties to better fit natural conditions is another way to protect natural resources. Also, crops should be grown for local consumption rather than for export when local conditions are not conducive to support both. This would achieve a better balance of production. This will also increase the number of people sustained by local crops. Again, this activity will be determined by policy. Developing countries must have access to affordable food, and local economies must generate enough growth so that decisions are not geared towards short-term economic gain.

Other solutions include better utilizing cropland. As much as 80 percent of the world's virgin tropical forests is cut to produce food. Deforestation depletes the ecosystems' limited nutrient capital, decimates plant and animal genetic diversity and accelerates global warming due to carbon dioxide and nitrous oxide emissions.[158]

Therefore, providing alternatives such as alley cropping, paddy rice production, legume-based pastures and continuous cultivation can help in alleviating or slowing short-term use and abandonment of these tropical forests. In the vast majority of the humid tropics, the soils are acid with low fertility. Farmers slash-and-burn forests to produce one or two crops of both rice and corn, averaging about one ton/ha of grain before leaving the land in a forest fallow. Then, they cut additional forests the following year.[159]

One obvious option is to first use intensively the best soils available in the area: the alluvial soils of moist humid tropical rivers which are naturally fertile but are not subject to annual flooding. The people in the Amazon of Peru have successfully adopted the traditional paddy rice production technology developed by Southeast Asian farmers. They are growing high yielding varieties suirable to the local tastes with appropriate agronomic practices. With low-cost supplement irrigation, farmers harvest two crops per

hectare annually. This is practice in over 50,000 hectares of the Peruvian Amazon under the leadership of Peru's National Rice Program. There is great internal demand for rice, a guaranteed price and sufficient infrastructure to deliver this basic food to the rest of the country.[160]

Traditional shifting cultivation involves a secondary forest fallow period of 4 to 20 years, to replenish soil nutrients and control weeds. Farmer experience around Yurimaguas indicates that an optimum age of fallow is about 12 years, but population pressures reduce this period to an average of 4 years. Slashing and burning young forest fallows result in faster grass weed invasion than would occur in older fallows because the seed pool declines with age. Considering the limited likelihood of long secondary fallow period in humid tropical areas, the need for an improved fallow is apparent. Research is currently underway to test various leguminous species as managed fallows, in addition to kudzu. We still do not know whether a second or third cropping cycle is sustainable. Research is underway.[161]

Another option is for the low-input system to serve as a three-year transitional period to intensive, fertilizer-based, continuous cropping systems. This is possible only in areas that have developed a sufficient road, credit, and market infrastructure. The field is ready for mechanized tillage, provided that slopes are suitable, because most of the felled vegetation has decomposed. This system has proven to be sustainable by continuously growing 40 crops for 17 years at Yurimaguas. In order to decrease weed infestation it is advisable to use a kudzu fallow before shifting to intensive crop production.[162]

Pastures for beef and milk production are an attractive option in the Latin American humid topics. Pastures are also in particular need of improved technology because of widespread pasture degradation. The low-input system can also serve as a precursor to establishing improved, acid-tolerant pastures, beginning with the clearing of secondary forests. Income-generating food crops can be grown, and the pasture species may be planted either vegetatively or by seed under a rice canopy. Several combinations of persistent, acid-tolerant grasses and legumes have produced high and sustained live-weight gains of the cattle in Yurimaguas for 8 years. Phosphorus and potassium fertilizers are applied annually or biannually. The kudzu fallow itself could be used as a pasture in rotation with grass-based pastures. Degraded pastures have been regenerated using similar techniques. Similar work has proven successful in the Amazon of Brazil.[163]

Such technologies, however, are useless without effective government policies that encourage, support and regulate them. Likewise, well-conceived policies will fail without sustainable technologies. Therefore the hope lies in a joint policy-technology approach: the Deforestation Reduction Initiative.[164]

The present situation is analogous to when the world technical assistance community launched the Green Revolution in the late 1960's. At that time sustainable technologies for high yielding rice and wheat production were sufficiently developed to be tested on a large scale. Key government officials were convinced of their importance by leading scientists, and instituted the necessary policies to make massive farmer adoption possible in India, Pakistan, Philippines, and other countries. The Green Revolution became a world-wide success during the next twenty years and the goal of arresting global famine was achieved. Unlike the Green Revolution the impact of the Deforestation Reduction Initiative will be gradual and less spectacular. This is because we are focusing on marginal ecosystems, and more complex technological and policy problems.[165]

A world-wide Deforestation Reduction Initiative will directly benefit the livelihood of both Third World countries and the developed countries. Sustainable agricultural options for the humid tropics are necessary, but they may not be sufficient to stop tropical deforestation. Coupled with appropriate, conservation-oriented government policies the following objectives can be achieved at the same time:

*Increased food and fiber production by farmers now practicing shifting cultivation.
*Reverse the pattern of degradation of the tropical forest already cleared.
*Preserve the remaining tropical forests with their rich genetic diversity.
*Reduce emissions of greenhouse gasses by as much as 20 percent.

These are solutions which can help reduce deforestation. They are not solutions which will contribute to feeding 10 billion people. However, these and other ideas must be incorporated into a overall strategy to protect tropical forests.[166]

Climatic Conditions

Most articles written on the impact of deforestation are difficult to assimilate. A study reported by the American Forestry Association more clearly illustrates the full force of this process. The average blue spruce will manufacture five pounds of pure oxygen per day. It will consume 48 pounds of CO2 per year, as it helps to combat the greenhouse effect. It will also provide the cooling equivalent of ten room-sized air conditioning units. An average tree, over a 50 year period, will do the following: generate $31,250 worth of oxygen, provide $62,000 worth of air pollution control, recycle $37,500 worth of water, and control $31,500 worth of soil erosion.[167] Trees are one of our most important assets. They are nature's lifeline, providing us with ameans of protecting our biodiversity and preserving our environment.

Thus the conclusion is that deforestation contributes to global warming. Estimates of agriculture's contribution to global warming vary greatly. However, as a result of agricultural encroachment into rain forests, most estimates attribute deforestation emissions to the agricultural sector. "Since deforestation accounts for 20 percent of all anthropogenic emission, this overstates the true agricultural contribution. Some over-estimate agriculture's contribution to greenhouse gases because they overlook net carbon emissions."[168] One thing is for certain, if high-yield agriculture can reduce deforestation, then emissions attributed to agriculture can be significantly minimized. This makes proper agricultural development even more valuable in preserving our environment.

One final note regarding the climate and its affect on agriculture. It has been argued that sunlight is presently the limiting factor for agricultural production. There does not appear to be any scientific evidence to support this claim. When de Wit (1967) multiplied integrated photosynthesis by the land area in each 10º belt of latitude, "The staggering conclusion...is that 1,000 billion people could live from the earth if photosynthesis is the limiting factor!" The sunlight received on land during warm days would energized the photosynthesis of far more than present yields. The high yields limited solely by solar energy would feed a population 100 times ten billion. Solar energy, warm days, and land will not limit food supply in the near future.[169] Therefore, through the application of new technology, increased use of conservation methods, natural and

ultra low rate pesticides, more productive hybrids, resistant strains of hybrids, biotechnology, and more efficient irrigation, high-yield agriculture will help meet the future demand for food. Also, when considering the alternatives, high-yield agriculture's contribution to maintaining the environment becomes critical.

Trade Policies

Trade policies should not encourage the development of agricultural cultivation at the expense of our natural resources. Trade should help establish conditions which allow for economic prosperity thorough long term strategies, not short term gain. Trade is the only means of balancing the resources and the needs of a global world. "The fundamental constraint to achieving sustainable development is social inequity and its associated evils."[170] Trade is an opportunity to attack these evils, to overcome poverty.

Severe poverty is primarily found in rural areas, areas where such poverty threatens biodiversity. "Rural communities are compelled to exploit resources for maximum gain regardless of future consequences for themselves, for the resource base or for biodiversity."[171] However, the proper trade policies can be a tool in addressing these issues.

These are complex problems and no single solution will solve them. One partial solution is to eliminate agriculture development in natural habitats. Specifically, natural habitat that is home to a wide variety of unique species. The only way to do this is to make food affordable and accessible, particularly to developing worlds. This cannot be accomplished without trade. It is no secret that the food produced is not equitably distributed, neither are the threatened assets of biodiversity. The stress on biodiversity becomes acute as the population grows in the areas that can least afford (from an environmental aspect) to develop intense agricultural production.

Trade among nations expands economic opportunities. It also makes food production and availability more predictable. Farm trade has been one of the important factors in improving American and European nutrition in the past two decades. It will be equally important for nutrition in Japan and other Asian countries in the two decades ahead.[172]

The real threat is not that the earth will run out of land, topsoil or water, but that nations will fail to pursue the economic, trade and research policies that can increase production of food, limit environmental damage and ensue that resources reach people who need them.[173]

This challenge must be met and the U.S. farmer, through technology and efficiency, will be part of the solution. Policies must be integrated to protect nature while strengthening weak economics. The U.S. cannot afford to lower our food safety standards and we must continue to strive for fair and equitable trade agreements. Without trade, it is inevitable that biodiversity will lose.

Urbanization

Urbanization may be seen as a moderate threat to agricultural production if viewed only on the basis of domestic food needs. However, when considering the consequences of losing highly-productive farm ground in relation to preserving biologically diverse habitat world-wide, urbanization becomes an extremely serious issue. For the most part the very best land is already in production, the loss of productive farm land ultimately requires the lost production to be replaced with less fertile land; land that results in less efficient use of resources, increased soil erosion, disruption to wetlands and watersheds and higher use of fertilizer inputs. As the best land is paved over by suburban sprawl, more acres of the marginal replacement land is required. This clearing can disturb habitats and destroy ecosystems, and when it occurs in developing nations, this is almost certain to be true.

"You can probably convince yourself," says NALS Executive Director Robert Gray, "That losing a million acres of cropland out of a 540 million-acre base is indeed a very small percentage in any given year, perhaps hard to get excited about. But over 4 years, if you lose 4 million acres, if it happens to be land of moderate productivity, that land would produce about the same amount of grain that is committed each year to foreign-assistance programs by all donor nations in the world. From the viewpoint of the world's needy people, setting aside 4 million acres in Iowa for use later in the century would indeed be viewed as significant." View the matter in narrow economic terms, and risk missing the point. Economics can neither define, measure nor assign responsibility in a matter that is ultimately a question of ethics. Inevitably, a country that has a land base capable of supplying 10 or 15 percent of the world's food supply must come to grips with the issue of whether it also has an obligation to protect and maintain that resource as best it can.[174]

When food production in this country is replaced by production in other parts of the world, the destruction of unique natural habitats and rare biological resources results. If all the land that was developed in the U.S. between 1967 and 1977 could be concentrated in one place, it would take an area larger than Ohio to contain it.[175] Between 1982 and 1992, Michigan alone lost farm land equal in size to the state of Rhode Island — 850,000 acres![176] Every year 1.5 million acres of productive U.S. farm land is lost to urban and suburban sprawl. Every week an area of farm land equal to the entire acreage of cranberries in North America — more than 30,000 acres — is replaced by shopping malls, subdivisions, and other icons of progress. That is equal to 180 acres an hour, or 3 acres per minute. "There's nothing more fundamental to American agriculture than the land, and yet we pave it over with little regard for the impact on future generations."[177]

Farm land is also the primary source of other benefits as well — environmental assets like open space, wildlife habitat, and watershed protection. It is shortsighted for a nation to incrementally take the best farm land for urban use s and then ask farmers to produce more with less. An American Farmland Trust (AFT) study concluded last year that 56 percent of U.S. agricultural production occurs in counties on the edge of major urban center.[178] **(Figure 21)**

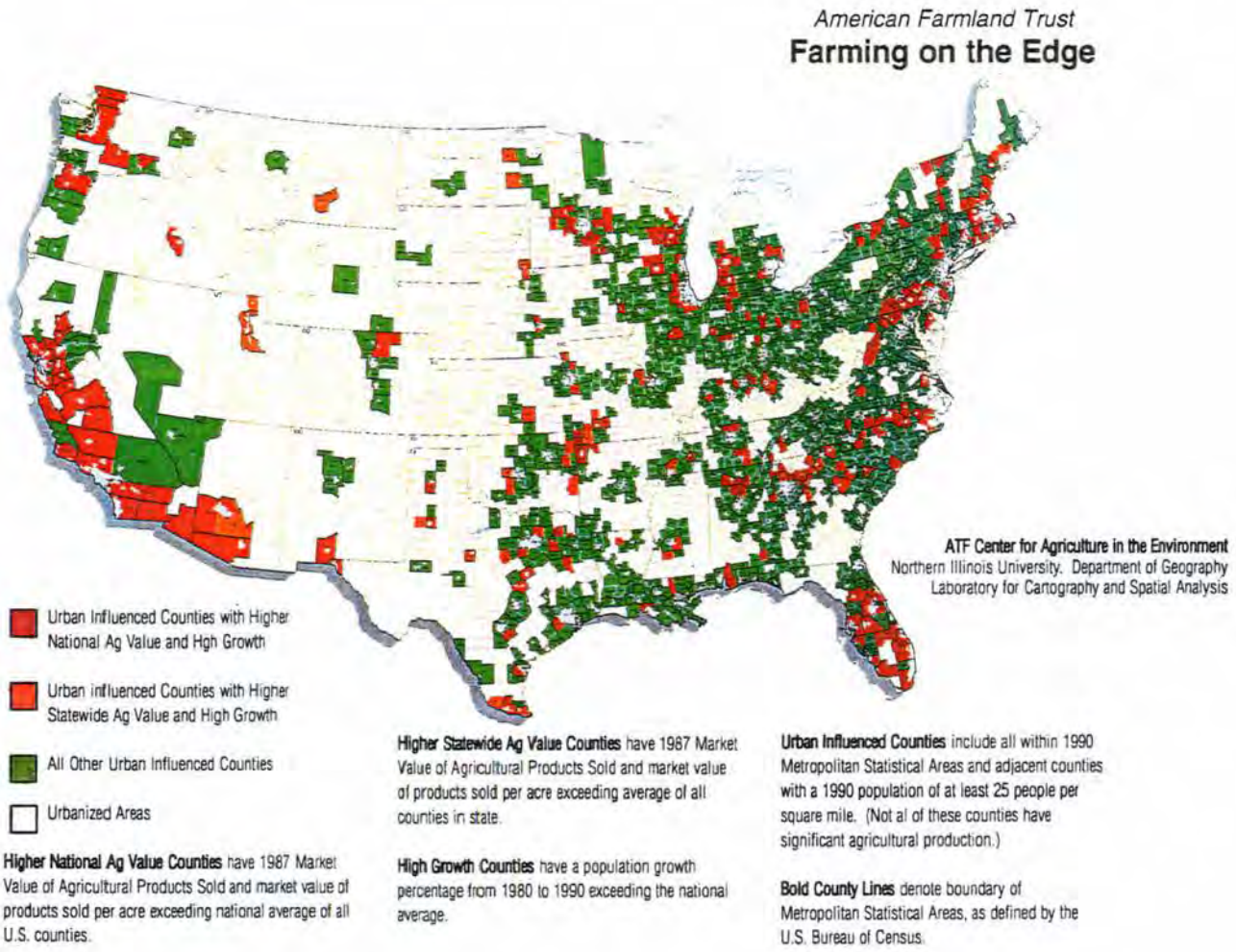


Figure 21. In ten years, between 1982 and 1992, 6 million acres of prime farmland in the U.S. were converted to some other use. This is equal to football fields laid end to end that would circle the world nearly 14 times.

According to the AFT, our soil conservation efforts will be wasted if we allow the soil on our best land to be covered with concrete. Each year in the U.S. we pave over an amount of soil roughly equivalent to the amount saved by the Conservation Reserve Program (700 million tons). Curbing non-point source runoff from farm land won't do much good if that land becomes a parking lot. Soil erosion on urban construction sites is ten to twenty times higher than on farm land utilizing conventional farming practices. It also hinders conservation efforts if this farm land is replaced with less-productive and highly-erodible land in other parts of the world.

The economics of urbanization have rarely been discussed, yet many of our suburban communities are just now recognizing the true costs of sprawling development. In a study conducted last year in Minnesota which mirrored earlier studies in Ohio, Massachusetts, and Connecticut, the conclusion was reached that farm land generates surplus funds in property taxes while residential development requires more funds for community services than it raises. In the three Minnesota cities studied, for every dollar of property tax revenue generated from residential development the towns spent $1.04 in public services, including education, fire and police protection, and roads. For farm land, the cities spent an average of 50 cents in services for every dollar raised. In addition, farm and natural lands provide benefits beyond their contribution to the tax base.

Agriculture creates jobs, supports local businesses, provides wildlife habitat, can be the preferred land use in urban watersheds and helps retain community character. Conservation, in addition to development, must be considered an important part of a municipality's economic profile.[179]

Many industries can pass on the cost of environmental protection to their consumers; farmers can not do this. For example, electric utility companies control air pollution with high tech scrubbers paid for by their customers. However, a farmer receives the same price for his commodities regardless of any additional expenditures directed toward environmental protection. Narrow profit margins and fluctuating returns make it difficult for farmers to absorb these costs on an individual basis. When a farmer is faced with the ultimate decision about the farm's future, whether to pass it on to the next generation, sell to another farmer, of subdivide, the financial reality of the latter often outweighs the decision to maintain the farm.

This issue has begun to be addressed through a program known as the Purchase of Development Rights (PDR). By purchasing the development rights (usually accomplished by acquiring a conservation easement) a public or private agency compensates the farmer for giving up the right to subdivide, the farm in return for cash compensation. This technique, use din conjunction with more traditional regulatory measures such as zoning, is seen as a more equitable approach to very difficult land use issues by recognizing the equity of the farmer. AFT officials say that 9 states and 70 local communities have PDR farm land preservation programs. Such programs are designed to offer the farm owner an attractive alternative to subdividing the farm in addition to providing a mechanism by which the rest of our society can share the cost of preserving the nation's most productive farm land. The U.S. has a long history of assisting its farmers in achieving conservation goals, but only now are we beginning to realize that much of that effort will be for naught if we allow the best land to be paved over and replaced by more fragile acreage.

Reducing the rate of loss of prime land in the United States will eventually have an impact on rain forest destruction. In a world anticipating a doubling of population in our lifetimes, food production lost from the most productive ground must later be replaced by a greater amount of less suitable land. In spite of the promises of new technologies, as a society we simply cannot continue to count on our scientists to compensate for our resource management mistakes. Even if technology can keep us ahead of the food demand curve it is still a more efficient use of capital and labor to produce food on prime land rather than marginal land.

The use of the world's natural resources, especially its most productive farm land, is a very complex equation involving the allocation of precious resources to a wide variety of competing interests. Much has been done to react to the more egregious problems of soil erosion, wetlands loss, and ground water depletion, but until recently the insidious loss of farm land to poorly planned urbanization has elicited very little response. In the U.S. the problem is complicated by a laissez faire approach to land management and a bias in favor of local control. Losing productive land here increases the threat to communities across the globe, and much of this occurs in a manner that attracts little attention, similar to other activities threatening our environmental resources.

The ecology of agricultural is not endlessly elastic, the additional stress created by non-agricultural development of the land base threatens permanently to reduce the productive capacity of American agriculture. This is why the efforts of states and counties to protect their farm land resources can no longer be viewed as isolated responses to purely local problems, irrelevant as a whole to agriculture. To the contrary, the rapid expansion of such efforts is urgent and crucial to the national interest.[180]

There is no longer reason to doubt that U.S. farm land is not just a private resource, or even a national resource of strategic significance. It truly has become an international resource of transcendent importance. Accordingly, the question arises as to what responsibility this generation has to protect a resource of such value for the benefit of other countries and of future generations here and abroad.[181] In terms of maintaining our world-wide biological assets, the answer is unequivocally that we must accept the responsibility here and now, or the consequences will go beyond the local impact.

Agriculture: Economic Impact

Agriculture as an industry is sometimes analyzed as if it were a stand alone component of a larger industrial base. Just the opposite is true. Agriculture is the base for a huge industry reaching millions of American workers. While agriculture plays an important economic role, it also plays a critical environmental role. The benefit of U.S. agricultural production is recognized through its efficiency, thus reducing land use required for food production, leaving millions of acres of natural habitat in tact. Unfortunately, the economic benefit of this system is often grossly underestimated.

With the number of farms and farmers steadily shrinking, the public often views agriculture as a declining industry. The facts, however, reveal an industry whose contribution to the Gross Domestic Product exceeds on trillion dollars and which is consistently the second largest positive contributor to the U.S. merchandise trade balance.[182] The perception that agriculture is limited to farm gate activity misses the dramatic growth in value-added industries that have developed over the past 30 years. If agriculture is to be properly evaluated for its contribution to the U.S. economy, all sectors must be considered. Within 25 years, non-food uses for agricultural products are expected to create 700,000 new jobs, increase farm income by $30 billion per year and contribute $100 billion annually to the economy.

The story of production agriculture is one of consummate efficiency. While the number of farms has decreased by nearly 40 percent since the early 1960's and the number of farmers has fallen to only 2 percent of the population, total farm output continues to expand.[183] Total farm output increased by over 33 percent in just the period from 1983 to 1991. Improved equipment, better farming techniques and advances in seed varieties allowed average farm size to increase to 473 acres from 352 acres in 1964.[184] American agriculture is becoming extremely efficient. What took 35 hours of labor to produce 30 years ago, takes 2 hours today. This efficiency makes the American farmer one of the most competitive in the world.

The contrast between efficient U.S. production and inefficient production elsewhere in the world is emphasized by an example in China. Peasants work small postage-stamp size plots, averaging less than an acre for a family of six. It takes a family about 60 workdays a year to cultivate their acre, where as a single American farmer does the equivalent work in about 2 hours or less. This efficiency translates into huge economic output.[185]

Farm output figures alone do not show the total economic impact of farm activity. Total farm assets reached $917 billion in 1994 and agricultural loans for the 1993/94 crop year were in excess of $61.5 billion. Cash receipts from farming exceeded $175 billion in 1993. These figures are impressive by themselves, but the economic impacts multiply when the income and employment associated with processing, transportation, wholesaling, retailing, marketing and trade of agricultural products is considered.[186]

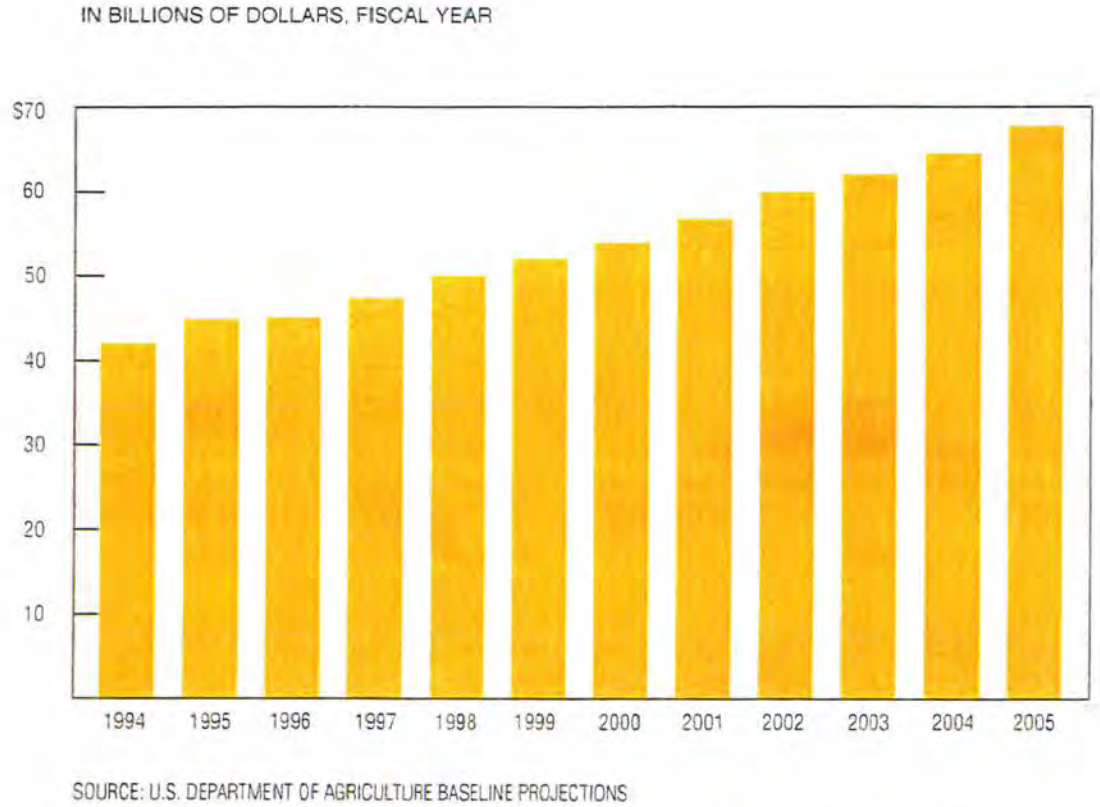
One measure of economic activity is the use of impact coefficients or multipliers. The food and related agricultural sectors create income and employment far beyond their initial yield. For example, the income multipliers associated with agricultural activities range from a low of 2.4 for oil bearing crops to a high of 11.9 for oils and fats processing. This means that every $1.00 of income from oil processing generates $11.90 in national income. Employment multipliers also demonstrate the benefit of value added agricultural activity. Employment multipliers range from 1.9 vegetables and fruits to 17.5 for oils and fats processing. Every person-year of employment within the oil processing industry resulting from a change in final demand generates 17.5 person-years in total employment in the United States. While farmers and ranchers comprise only 2% of the U.S. labor force, an additional 16% of Americans are employed in the food and fiber sector of the U.S. economy. Overall, food and fiber activity comprises 18% of the U.S. economy or over $1 trillion per year.[187] **(Figure 22)**

Figure 22. The U.S. farm sector is the largest single segment of the U.S. economy, generating 18 percent of GDP and employing over 22 million people.

Agriculture's impact on trade is also impressive. In fiscal year 1994, agricultural exports totaled $43.5 billion. Every dollar in agricultural exports generates another $1.59 in economic activity such as transportation and financing. Agriculture contributed a positive $17.2 billion to a merchandise trade deficit of $163 billion in fiscal 1994. Agriculture accounts for 10 percent of all U.S. exports.[188] U.S. agriculture is less than one

fourth of 1 percent of the world's labor force, yet it produces 50 percent of the world's soybeans, 40 percent of the world's corn, 25 percent of the world's beef, 15 percent of the world's cotton, and 11 percent of the world's pork and 10 percent of the world's wheat. This is a significant contribution to the world's food supply, representing 66 percent, 78 percent, 12 percent, 28 percent, 10 percent, and 36 percent respectively of the total world exports of these products. With world population expected to double in the next forty years, agriculture will continue to be a major contributor to U.S. exports and world food supplies. **(Figure 23)**

AGRICULTURAL TRADE VALUE



SOURCE: U.S. DEPARTMENT OF AGRICULTURE BASELINE PROJECTIONS

Figure 23. The value of U.S. agricultural exports is expected to rise from $43.5 billion in fiscal 1994 to $55 billion by fiscal 2000 and surpass $68 billion by 2005.

The importance of agriculture to the economy is also manifest in the quality, safety and relative low cost of food in the United States. Food quality helps to explain the increase in the average life span of a child born in the U.S. to 74.7 years. In addition to quality and variety, food costs, as a percent of disposable income, are lower in the U.S. than any other country at 11.2%. This enables U.S. citizens to maintain a higher standard of living. Each individual U.S. farmer now produces on average enough food for 128 people, the most productive in the world.[189]

While achieving this efficiency in productivity, U.S. agriculture has increased it's economic base. It is projected that if the U.S. expanded its agricultural production by 20% over the next 8 years, farmers would gain $4 billion in net income, national and rural economies would gain $29 billion in economic activity, 225,000 jobs would be created, and supporting industries would benefit by another $4 billion.[190] This can be done...not at the expense of the environment, but as a contribution to the environment. The threshold of environmentally responsible agriculture must be a fair and reasonable risk assessment and cost benefit. U.S. agriculture is in a unique position to accomplish environmental and economic goals simultaneously.

Finally, the U.S. economy benefits from agriculture's concern with environmental issues. Farmers are the original stewards of the land and in 1989 over $3 billion were spent on conservation measures for U.S. farm land. Agriculture realizes the importance of maintaining the productive base for an industry that touches all part of the U.S. economy. When major alterations to high-yield production agriculture are discussed, the impact in economic terms cannot be ignored. Few segments of the economy can generate this enormous amount of wealth while protecting environmental resources worldwide.

Conclusion

In the long run, the success of high production agriculture's contribution to the maintenance of our biodiversity will depend upon the ability of the United States and other countries to develop a balance between agriculture and biological resources. The policies determining both the distribution and use of these natural resources will affect the long term sustainability of our capacity to meet future needs. The failure to properly implement these policies will mean the degradation of the two most critical resources our world has today (agriculture and wildlife habitats). It is important that we recognize the value of high-yield agriculture in the effort to maintain our biodiversity. Our failure to do so will accelerate the demise of biological resources in tropical forests, wetlands, woods and deserts. This loss will mean foregone opportunities for all of humanity. We have the means to use agriculture to our advantage; we can develop a sustainable model to maintain biodiversity. The question remains, do we have the will and the commitment?

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