Chapter III

Underexploited Plant and Animal Resources for Developing Country Agriculture

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INTRODUCTION

The 1940s was the decade of wonder chemicals. The miraculous properties of DDT, sulfa drugs, herbicides, nylon, and plastics blinded us to the potentials of nature. Laboratories were limitless, nature seemed limited. Manmade was modern, nature seemed passe. Subsequent decades seemed to confirm the euphoric view; we gave up seeking our new product needs in the kingdom of nature, the previous wellspring for civilization's advances.

As a result, as we move toward the 21st century, we rely on fewer and fewer plants and animals. We ignore, or have forgotten, thousands of useful species that could broaden and balance our fount of resources. All this, in face of the recognition that within a few short decades the petrochemical explosion that began in the 1940s will be snuffed out.

However, a big change is now occurring in the scientific community. Researchers are returning to nature's storehouse to take stock of its genetic possibilities; to scrutinize species that could make useful new crops and domestic animals. Some of them are species that are wild and untested, some even poorly identified. Though they work largely out of the public eye, these dedicated researchers are quietly germinating ideas and laying roots that will grow with and shape our future. Some natural products now virtually unknown are likely to become mainstays of world agriculture.

Decisionmakers, entrepreneurs, and the general public should pay more attention to these researchers' results. A groundswell of support for the development of new species could lead to a cornucopia of new foods, fuels, and industrial feedstocks. It may help extend productive agriculture to vast regions that today are not arable. It may help raise from despair the ever increasing numbers of humans in developing countries who waste their lives away in malnourished poverty. It may show how to cultivate crops that produce raw materials that now come from petroleum. It's a challenge. But some of the future's best resources are out there waiting in nature.

PLANTS

Botanists and ethnobotanists can reel off long lists of obscure plants that seem to warrant recognition. Respondents to recent questionnaires sent out by the National Academy of Sciences named over 2,000 plant species that deserve much greater recognition. Almost none have been given agronomic attention. A few striking examples are given below.

Poor People's Plants

A friend recently told me that he had discussed the winged bean with an influential Filipino family. "They were incredulous that such a miraculous plant could exist, " he said. "SO, on a hunch, I took them out back to the servant's quarters. There, climbing along a fence, was a winged bean plant laden with pods."

" 'But that's just sequidillas,' they said, disappointment echoing in their voices. 'It's only a poor man's crop!' "

It is a universal phenomenon that certain plants are stigmatized by their humble associations. Scores of highly promising crop plants around the world receive no research funding, no recognition from the agricultural community; they are ostracized as "poor man's crops. "

For information on a poor people's crop one has to turn, more often than not, to botanists and anthropologists; only they will have taken an interest in the plant. Often there has been no agricultural research on it at all—no varieties collected or compared, no germination or spacing trials, no yield determinations or even nutritional analyses. And yet the crop actually may be crucial to the lifestyle—even the survival—of millions of people.

Just 50 years ago, the soybean itself was a poor people's crop. In the United States, it was spurned by researchers for more than a century after Benjamin Franklin first introduced seeds from the Jardin des Plantes in Paris. To be a soybean advocate then was to risk being considered a crackpot. Early in this century, Americans still considered the soybean a second-rate crop fit only for export to "poor people" in the Far East. But then, in the 1920s, University of Illinois researchers established a comprehensive soybean research program that helped sweep aside this discrimination. The soybean acquired new status as a "legitimate" research target, and its development gained so much momentum that it is now the world's premier protein crop.

Nowhere is the neglect of poor people's crops greater than in the Tropics—the very area where food is most desperately needed. The wealth and variety of tropical plant species is staggering. Some of the Third World's best crops are waiting in the poor people's gardens, virtually ignored by science. Merely to have survived as useful crops, suggests that the plants are inherently superior. Moreover, they are already suited to the poor person's small plots and mixed farming, as well as to poor soils, and the diet and way of life of the family or village. Examples are the winged bean and amaranths.

Winged Bean

Perhaps no other crop offers such a variety of foods as the winged bean. Yet it, remains a little-known, poor person's crop, used extensively only in New Guinea and Southeast Asia.

A bushy pillar of greenery with viny shoots, blue or purple flowers, and heart-shaped leaves, the winged bean resembles a runner-bean plant. It forms succulent green pods, as long as a man's forearm in some varieties. The pods, oblong in cross-section, are green, purple, or red and have four flanges or "wings" along the edges. When picked young, the green pods are a chewy and slightly sweet vegetable. Raw or boiled briefly, they make a crisp and snappy delicacy. Pods are produced over several months and a crop can be collected every two days, providing a continuous supply of fresh green vegetables.

If left on the vine the pods harden, but the pea-like seeds inside swell and ripen. When mature, the seeds are brown, black, or mottled. In composition they are essentially identical to soybeans, containing 34 to 42 percent protein and 17 to 20 percent of a polyunsaturated oil. The protein is high in the nutritionally critical amino acid lysine.

In addition to the pods and seeds, the winged bean's leaves and shoots make good spinach-like potherbs. Its flowers, when cooked, are a delicacy with a texture and taste reminiscent of mushrooms.

But perhaps the most startling feature of the plant is that, below ground, it produces fleshy, edible tuberous roots. These are firm, fiberless, ivory-white inside and have a delicious and delicate nutty flavor. The winged bean is therefore something like a combination of soybean and potato plants. And winged bean tubers are uniquely rich in protein—some contain more than four times the protein of potato.

Amaranths

Amaranths—major grain crops in the tropical highlands of the Americas at the time of the Spanish Conquest, They were staples of both Aztec and Inca. But the conquistadors banned the cultivation of amaranths because the grain was a vital part of native religion and culture. With this political move the Spanish struck a blow for their church but they also crushed the crop. For 500 years little has been done to study or promote it,

Amaranths belong to a small group of plants, termed C_4, whose photosynthesis is exceptionally efficient, The sunlight they capture is used more effectively than in most plants and amaranths grow fast. Vigorous and tough, amaranths have been termed self-reliant plants that require very little of a gardener. They germinate and adapt well to the rural farmer's small plots and mixed cropping, Furthermore, they are relatively easy to harvest by hand and to cook.

Amaranths are annuals that reach six feet in height and have large leaves tinged with magenta. They are cereal-like plants producing full, fat, seed heads, reminiscent of sorghum. The seeds are small but occur in prodigious quantities. Their carbohydrate content is comparable to that of the true cereals, but in protein and fat amaranths are superior to the cereals.

When heated, amaranth grains burst and taste like popcorn. In many regions, however, the grains are more often parched and milled. Amaranth flour is high in gluten and has excellent baking qualities; bread made from it rises and has a delicate nutty flavor,

Recently, W. J. S. Downton, an Australian researcher, has found that the grain of at least one amaranth (Amaranths caudatus var. edulis) is rich in protein and exceptionally rich in lysine, one of the critical amino acids usually deficient in plant protein. Indeed, the amount of lysine exceeds that found in milk or in the high-lysine corn now under development.

Conclusion

It is very hard to get grants for research on poor person's plants. Funding agencies resist; the plants are unknown to most of them, and the literature to support any claims may be sparse.

Nonetheless, it is now time for agricultural research facilities throughout the world to incorporate poor person's crops into their research efforts. Third World agricultural development needs this balance, for only when his own crops are improved will the poor man be able to feed his family adequately. In future decades it may be–as in the case of the soybean—that today's poor person's plants will be feeding the world,

TREE LEGUMES: SHOCK TROOPS FOR THE WAR ON DEFORESTATION

Man has deforested one-third of South America's native forests, one-half of Africa's, and two-thirds of Southeast Asia's, It is critically urgent that the remaining forest cover be protected from indiscriminate harvest and that many now-deforested regions be reforested. A "thin green line" of fast-growing leguminous trees may be either our last line of defense or our first line of attack.

To most people legumes are limited to the dining table, but to plant scientists legumes include not only vegetables but shrubs, vines, and thousands of tree species, most of them indigenous to the Tropics. Actually, the family Leguminosae is the third largest in the plant kingdom. But out of the 18,000 different species of legumes, farmers extensively cultivate only about 20 species including peas, beans, soybeans, peanuts, clover, alfalfa, and even licorice. Foresters cultivate almost none.

The potential of tree legumes as useful plantation species remains largely unrecognized, yet they offer a particularly promising area for exploration in these days of devastating deforestation. Indeed, they seem to have special attributes that could put them in the front lines of the battle to reclothe the scarred hillsides throughout the Tropics.

Legumes, for example, are nature's pioneers in plant succession. They are among the first plants to colonize bare land. It therefore seems ecologically wise for man to deliberately exploit them for the same purpose: to quickly revegetate eroding or weed-smothered terrain, to halt erosion, and to provide protective ground cover under which slow-growing, climax-forest species can regenerate. Furthermore, many wood requirements might be met by these quick-growing small trees and they could help spare the last remnants of the natural forests.

Many woody legumes have a hardy, irrepressible character, suited to a wide range of soils, climates, altitudes, and environments. Like other pioneer species, they have a precocious nature and grow quickly in an attempt to overtop and preempt the space of their plant competitors.

Because of this innate competitiveness, many tree legumes are easy to establish and cultivate. Some can be direct-seeded (avoiding the expense of nurseries and transplanting fragile seedlings), and in some tests even spraying their seed out of aircraft has proven a suitable way to establish plantations. Many occur naturally in dense, pure stands, suggesting that they probably can be grown in monoculture without being decimated by pests.

A most important feature of many legume species is that nodules on their roots contain bacteria, which chemically convert nitrogen gas from the air into soluble compounds that the plant can absorb and use. Thus, for average growth these species require little or no additional nitrogenous fertilizer. Some produce such a surfeit of nitrogen—largely in the form of protein in their foliage—that they make excellent forage crops and the soil around them becomes nitrogen rich through the decay of fallen foliage.

To give an idea of the potential of this class of trees, three species of fast-growing legumes are mentioned below. Not one of these trees is widely exploited so far.

Loucaena

In the 1960s, University of Hawaii professor James Brewbaker found in the hinterland of Mexico certain varieties of *Leucaena leucocephala* that grow into tall trees. This was unexpected because the plant was previously known only as a weedy bush. In tropical climates, Brewbaker's varieties have grown so tall and fast that they can be twice the height of a man in just six months; as high as a three-story building in two years; and as tall as a six-story building with a trunk cross-section as large as a frying pan in only six or eight years.

In the Philippines, one hectare of these tall leucaenas has annually produced over *10* times the amount of wood per acre that a well-managed pine plantation produces in the United States. Even among the world's champion fast-growing trees, this is exceptional.

Leucaena wood is thin barked and light colored. For such a fast-growing species, it is remarkably dense (comparable to oak, ash, or birch), strong, and attractive. Its fiber is acceptable for paper-making and the wood can be pulped satisfactorily and in high yield.

But leucaena, a multipurpose plant *par excellence,* also has other uses. It can supply forage, for example, and researchers in Hawaii and tropical Australia have found that cattle feeding on leucaena foliage may show weight gains comparable to those of cattle feeding on the best pastures. Leucaena wood also makes excellent firewood and charcoal. Further, the plant is a living fertilizer factory for if its nitrogen-rich foliage is harvested and placed around nearby crops they can respond with yield increased approaching those effected by commercial fertilizer.

Although arboreal leucaena varieties have been cultivated for only a decade or so, they are already being planted over tens of thousands of hectares in the Philippines. The WorId Bank has funded one large program, Batangas Province has a nursery producing 10,000 leucaena seedlings daily. The province's dynamic governor, Antonio E. Leviste, has decreed that other nurseries be set up throughout his province: in churchyards, cemeteries, schoolgrounds, roadsides—any idle ground. No government employee gets a paycheck until he has set up a leucaena plantation with at least 20 trees to produce seed, The consequent greening of Batangas has made citizens keenly appreciative of deforestation's ugliness and problems, as well as reforestation's rewards. Tree planting now interests the Batangas public intensely—not entirely for the sake of revegetating eroding watersheds, but for the income and benefits from exploiting leucaena forage, fuelwood, and "green manure. " That the program has been adopted with gusto by the citizenry demonstrates the relevance of tree legumes to tropical problems as a sort of "appropriate forestry. "

In more remote southern islands of the Philippines, Ieucaena (Filipinos call it ipil-ipil) is being planted over huge areas of former green-deserts, wastelands lost to coarse, sharp-edged "cutting-grasses," With its vigor and persistence, leucaena—if given a little care—can overtop the grasses, shading them out of existence, and converting waste ground to productive forest. It is essentially a permanent forest because after felling, the stump of a leucaena tree regrows with such vigor that the plant is said to literally "defy the woodcutter. "

Calliandra Calothyruas

In 1936, horticulturists transported seed of this small Central American tree to Indonesia. They were interested in it as an ornamental, for like other *Calliandra* species, it has flowers that are gorgeous crimson powder-puffs, glowing in the sunlight like red fireballs. But Indonesians instead took up *Calliandra calothyrus* as a firewood crop. Indeed, for 15 years steadily expanding fuelwood plantations of it have been established until they now cover over 75,000 acres in Java.

This small tree—barely taller than a bush—grows with almost incredible speed. After just one year it can be harvested. The cut stump resprouts readily giving new stems that can be *10* feet tall within six months. Some trees in Indonesia that are 15 years old have been harvested 15 times!

Calliandra wood is too small for lumber, but it is dense, burns well, and is ideally sized for domestic cooking. It is also useful for kilns making bricks, tiles, or lime and for fueling copra and tobacco dryers.

Indonesian villagers now cultivate *Calliandra calothyrus* widely on their own land, often intercropping it with food crops. The plant's value is dramatically exemplified by the village of Toyomarto in East Java. There, land that was once grossly denuded and erosion-pocked is now covered with calliandra forest and is fertile once more. Today the villagers actually earn more from selling calliandra firewood than from their food crops.

Conclusion

These are brief descriptions of only two species of small leguminous trees that have recently proven useful in combating deforestation in Southeast Asia. There are many other exciting species. In South Korea, foresters intercrop bushy *Lespedeza* species to provide firewood during the early years of the establishment of pine and other forests. In Central America, there are *Enterolobiurn cyclocarpurn* and *Schizolobium parahyba,* in South America, *Mimosa scabrella (M. bracatinga), Schizolobium amazonicum,* Tipuana tipu, and *Clitoria racemosa;* and in the Pacific Islands, *Albizia minahassae* and *Archidendron oblongum*. In Africa, several fast-growing *Albizia (A. adianthifolia,* and *A. zygia,* for example) are indigenous, and two legume trees introduced from India, *Acrocarpus fraxinifolius* and *Dalbergia sissoo,* have shown exceptional growth rates on appropriate sites. In Asia, there are also *Acacia auriculiformis* and *Sesbonia grandiflora*.

In foresters' terms many of these species have "poor form," Their trunks may be too narrow or too crooked for construction timber or veneer. But, these are species for "peoples' forestry." Their role is for:

- farms, backyards, pasture lands, roadsides, canal banks and fencelines;
- village woodlots and energy plantations to fuel kilns, electricity generators, cooking stoves, and crop dryers;
- agrisilviculture (agroforestry), because they provide a wealth of products including forage, green manure, and food;
- use in shifting cultivation, because the natural drop of protein-rich leaves, pods, and twigs contributes nitrogen organic matter and minerals to upper soil layers and can markedly speed up the rebuilding of worn out soils;
- quick-rotation cash crops, both for the private landowner and the government forest department; and
- utility purposes such as beautification, shade, and shelter belts.

ANIMALS

When early farmers discovered that animals could be tamed and managed, they eagerly experimented with many of the species surrounding them. In Asia and the Americas, the silkworm, yak, camel, water buffalo, llama, alpaca, and guinea pig were selected. Egyptian tomb paintings at Saqqara painted in **2500** B.C. show addax, ibex, oryx, and gazelle wearing collars and obviously domesticated. Ancient Egyptians apparently domesticated hyenas and baboons, as well.

But then the process essentially stopped. Today's farmers raise the same animals their Neolithic forebears were familiar with more than 10,000 years ago. (One exception is the rabbit, which French monks tamed between the 6th and 10th centuries because the Church considered newborn rabbits to be fish and they could be eaten when the Church calendar demanded abstinence from meat.) Although the world's menagerie contains some **4,000** species of mammals alone, only a mere six domestic animals produce virtually all of the world's meat and milk.

As agricultural man spread himself about the globe, he dragged with him this handful of species. He carried them beyond their natural boundaries, forced them upon strange and often fragile environments—usually driving out the native species that previously predominated there, and often drastically changed the environments to accommodate them.

Very little meat is eaten in developing countries and because most of them are in the Tropics, it is not possible to change that much with cattle, sheep, and pigs. These animals have an evolutionary adaptation to the temperate environments from which they originated and are limited in their ability to adapt to new ones. But the world's fauna is a rich genetic bank that may be tapped to increase world food production. Some of the potential species are unexpected ones, as highlighted below.

Toads, Snails, and Guinea Pigs

In rural areas of developing countries, it is important to produce small animals. They fit better into village life and they can be eaten at one meal, so the lack of refrigeration is no hindrance. In Chile, there's a shiny, olive green toad *(Calyptocephalella caudiverbera).* It is a giant toad that can weigh three pounds or more. Its meat tastes like a cross between lobster and chicken. It grows to be a foot long or more and lacks the toxic skin glands and warty appearance of other toads. Because of its superb and enigmatic taste, the wild toad has long been a delicacy of Chilean gourmets. But now, researchers at the La Serena campus of the University of Chile are learning how to farm them.

In 1975, the University's Institute of Food Technology started farms large enough to produce 100,000 of the choice toads every two years. The intensive methods they developed have made it feasible to supply 10 to 15 tons of scallop-sized toad legs each year to grocery stores, restaurants, and canneries.

The Institute also has dug production ponds out of otherwise useless swampland. The eggs, larvae, tadpoles and adults are all kept apart because the voracious toads have no hesitations about cannibalism. Normally, however, they feed on small fish, crabs, crawfish, and aquatic plants. The ponds are surrounded with flowers and shrubs to attract insects and boxes of rotten fruit are placed nearby to draw fruit flies to the area. With their long sticky tongues, the toads eagerly capture the insects, Other than this, the toads reportedly are given little attention and in two years they reach market size: about 7 inches long and weighing one-half pound.

Researchers are ecstatic over the ease and cheapness of toad farming, and they are looking toward the lucrative international frog meat market to export the tender, white drumsticks of these unique Chilean toads.

In Nigeria, the Institute of Oil Palm Research is developing another potentially valuable new resource: the giant African Land snail (Achatina species). This snail grows rapidly and may weigh up to half a pound. It is eaten widely in West Africa and is immensely popular in parts of Nigeria and Ghana. The meat has as much protein as beef, but it has considerably more of the important amino acids, lysine, and arginine, than even eggs contain. The Institute has found the snails suitable for “farming” in shaded enclosures under the trees in rubber, cocoa, or oil-palm plantations. With proper proportions of males and females, it has produced as much as 150 pounds of snail meat in the small enclosures each year,

In Peru, scientists are looking to their indigenous fauna too. One of Peru’s serious and permanent problems is a lack of beef. Two-thirds of the steaks of which Peruvians are so fond are imported despite the nation’s chronic dollar shortage. The situation became so serious that five years ago the military junta put a ban on beef consumption 15 days in every month. Chicken production was once believed to be the answer to the problem, but although it has grown fast, so has the population. Big hopes were placed on fish, too, but the country lacks the financial resources to install the facilities needed for national marketing. The guinea pig is now believed to be the best answer so far to the problem posed by the short supply of animal proteins.

Guinea pig is a traditional staple. Although domesticated in the time of the Inca, it has not previously attracted much research attention. Yet guinea pig is widely consumed in Peru. The nutritional value of its meat compares favorably with that of other meats. The animals can be raised in urban areas and in villages, where larger animals are scarce or impossible to keep. The fast growth and rapid reproduction makes the guinea pig a sensible resource in the Peruvian environment, Added to this is the fact that guinea pigs can live off vegetation that is of inadequate nutritive value for feeding other livestock.

These resources are strange—even repugnant—to the majority of specialists working to increase food production and improve human nutrition in developing countries. But to the local inhabitants they are traditional foods that are much sought and enjoyed.

Crocodiles

In Africa, South and Southeast Asia, Australia, and South America, the populations of crocodiles, alligators, and caimans are fast headed for extinction. In Papua New Guinea (P. N. G.) in the 1960s, the two native crocodile species were headed the same way. But not today. In the last five years, a remarkably innovative project in this, one of the newest and most underdeveloped nations, has caused a dramatic turnaround in the crocodile’s drastic decline there. Though the P.N.G. story has not been told widely, it is one with immense implications for the survival of crocodilians elsewhere. It is also a demonstration of how resources can be managed to conserve a species, to minimize impact on a fragile environment, and to provide wealth in remote villages in a developing country.

The P,N.G. program is based on an appreciation for crocodile biology. Each year, a female may lay between 30 and 70 eggs. Although most of them hatch, predators so relish the tender and remarkably vulnerable young hatchlings that almost none survived the 15 years needed to reach breeding size. In nature, then, there can at any time be found a plethora of tiny crocodiles, but a paucity of breeders. Commercial hunting worsens the imbalance because hunters always seek the biggest specimens, regardless of the resulting damage to the breeding populations.

Recognizing that a ban on hunting would be largely unenforceable in remote areas (and grossly unpopular where man-eaters sometimes occur), the P.N.G. Government decided in 1970 to restructure the trade so that shooting breeders would lose its attraction and the profit would come from exploiting the hordes of tiny hatchlings that would result. This was done through a law banning the sale of large skins, supplemented by a stiff tariff on small skins.

Today, villagers in the steamy swamps of P.N.G. have tens of thousands of tiny crocodiles in their care. They raise them for a year or two and can sell them for up to *$100* each. Crocodile farming has already become the main cash earner for the people there. I personally met a village leader in Wewak who had come to oversee shipment of $14,000 worth of skins headed to New York by airfreight.

The P.N.G. crocodile project is characterized by:

- *Good Science:* Despite popular "man-eater" impression, crocodiles live mainly on fish, though the researchers in P.N.G. have found that young ones also grow well on frogs, snails, and beetles. The feeding efficiency is astounding: One and one-half pounds of food gives one pound of weight gain, and foot-long animals can grow to be five and six feet long in less than two years. (Conventional domestic livestock require five to eight pounds of food to produce one pound of weight gain.) Crocodile farming is also space efficient: dozens of animals are raised in an area the size of a household living room; in a swamp or jungle, that's important.
- *Good Conservation:* Because the program is based on harvesting young hatchlings from the wild, the economic value of the wild populations and their habitats becomes forcefully apparent. The program's future depends on them. It gives economic value to wildlife protection. Out of pure self-interest, the people become guardians and conserves of habitats and wildlife. In a sense, the farming project is just a tool for conserving the species in its own wild habitat.
- *Good Sociology:* The villagers have a sophisticated knowledge of the crocodile; the animal is part of their culture and heritage. They don't have to be taught how or where to catch crocodiles, and they take quickly to the program. Introducing cattle or Western-style crop-raising would require massive and tedious education and training.
- *Good Environmental Management:* The program is based on living with the existing landscape and resources. It requires none of the bush-clearing fencing, forage-grass planting, or pesticide spraying that rearing other domestic animals would demand. That's important in a fragile tropical rainforest ecosystem.
- *Good Economic Development:* What other agricultural product could give a $14,000 income in a remote jungle village?

Butterflies

In remote jungle towns in the north of Papua New Guinea are operating butterfly farms—some of the most unusual farms in the world. Around the edge of a field, flowering shrubs are planted to attract the adult butterflies whose mouthparts are adapted for drinking nectar from flowers. These butterfly "forages" include hibiscus, flame-of-the-forest, and the strange, pipe-like aristolochia. Within half-acre circlets of these flowers are planted leafy plants that the caterpillars feed on. The combination provides a complete habitat where butterflies find everything they need for their life cycle. Thus few leave, and the farmer retains his livestock without fencing or walls.

Butterflies may seem exotic livestock to us, but even in the remotest P.N.G. jungle, a villager knows and understands their habits, location, and lifestyle. And butterflies don't require bank loans, veterinary services, artificial insemination, or the other impediments of conventional livestock. Also, when farming insects, the villager can work when and if he wants to: there are no deadlines, No hard labor and no danger, either. To a Papua Guinean, the strange thing is that people are willing to pay for a butterfly.

And pay well they do. Ounce for ounce, exotic butterflies are far more valuable than cattle. And worldwide demand for butterflies is rising. Millions are caught each year and sold to museums, entomologists, private collectors, and perhaps most of all, to ordinary citizens. The fragile, iridescent creatures, mounted in plastic, decorate purses, trays, tabletops, screens, and other ornamental objects.

With their butterfly farms many rural Papua New Guineans are for the first time participating in a cash economy and butterflies are beginning to improve the welfare of many villages. At Bulolo, the government has established an insect-buying agency to help the butterfly farmers of Papua New Guinea. It purchases insects from farmers and fills specific orders requested by overseas buyers. Profits go to the villager.

Perhaps the most striking feature of the program is that it is actually conserving, and even increasing, the numbers of butterflies. Basically, it is an exciting, pioneering conservation project because it develops a tremendous economic incentive to preserve populations and habitats–the program relies on healthy wild populations to keep the farms stocked.

Because of this, conservation organizations are becoming excited by the program, seeing in it a model that could be duplicated to help save endangered exotic butterflies everywhere.

FUEL

The fuels paradise of recent decades has blinded us to the possibilities of alternative energies, especially those for powering vehicles. The internal combustion engine, however, remains the most immediately practical prime mover for motor transport. Finding alternative energy sources for it poses one of the most severe problems facing the world. The world is not so much running out of energy as it is running out of liquid and gaseous fuels. Living plants that produce liquid fuels would indeed be boons for the future. Farmers would become energy producers. Today this is already a distantly glimpsed possibility. Two examples are given below.

The Gasoline Plants

Near Irvine in southern California can be found a field of what is perhaps the most revolutionary and little-explored development in modern agriculture. The crop is *Euphorbia lathyris* and this field is the first attempt at cultivating this wild cactus-like shrub. It is the brainchild of Melvin Calvin, professor of chemistry at the University of California at Berkeley. *Euphorbia lathyris* and related species produce a milky latex, one-third of which is composed of hydrocarbons—compounds similar to those found in crude petroleum oil. Although there are as yet few hard facts on which to base firm projections, Calvin estimates that the plants might be capable of each year producing *10* to *50* barrels of oil per acre.

The hydrocarbon in *Euphorbia lathyris* and similar species is principally polyisoprene, the same molecule that makes up rubber in the rubber tree. But in *Euphorbia*, it is liquid rather than solid. This is because it is a smaller molecule, but Calvin points out that its hydrocarbon molecules are similar in size to those found in crude oil. He thinks that *Euphorbia* type hydrocarbons might even be processed into fuels and petrochemicals in existing oil refineries.

A distinguished scientist, Calvin received the *1961* Nobel Prize for Chemistry in recognition of his achievements in unraveling the chemical processes of photosynthesis. Growing petroleum plants is a new venture for him, but already he projects that this country's vast petroleum demands could be met by plantations covering an area the size of the State of Arizona. He calculates the costs of harvesting petroleum from trees to be competitive with current oil prices: a total of between $5 and $15 per barrel for growing and processing the plants.

A plantation of such plants should be economic in dry lands unsuitable for growing food, Though little is known of their requirements or yields, *Euphorbia* species are hardy and need little or no irrigation and care. Calvin foresees that the plants will be mowed near the ground and the harvested plants crushed to release latex in much the same fashion as is done with sugar cane. The stumps quickly resprout new stems so that replanting would be unnecessary.

This is truly a pioneering concept, and the field near Irvine is the first small step in evaluating its practicality. Already, larger plantations are planned. The University of Arizona has a million-dollar grant from the Diamond Shamrock Corporation to develop *Euphorbia lathyris* into a crop; the Government of Kenya is investing (perhaps unwisely) *$10* million in plantations. If such projects are successful, this obscure wild plant will enable the world's desert countries to have oil fields on top of the ground.

Diesel Fuel You Grow on the Farm

Ohio State University (OSU) in Columbus, Ohio, transports students around its spread-out campus using a fleet of buses. Nothing unusual in that. But, this year *(1980)* OSU is using soybean oil as fuel.

Over the past decade, various student projects at the OSU engineering school have shown that vegetable oils can be used as fuel for diesel engines. For a full year the university has run a large, 60-passenger bus partly on soybean oil. The experiment proved so successful that in September the whole university fleet was switched to the new fuel.

The soybean oil is collected from deep-fat fryers in cafeterias and kitchens across the University, filtered through muslin cloth by the engineering students to remove gunk and solids, and blended into diesel fuel. A ratio of one part soybean oil to four parts diesel was settled on as it gave a stable mixture, lowest fuel consumption, and actually smoked less than diesel fuel alone.

The first bus maintained its normal **40** hour a week schedule. After 4,5oo miles on the soy-diesel blend the engine was taken apart and inspected. Little or no abnormal wear had occurred. The engine was actually in such fine shape that it was merely reassembled and returned to service without further attention.

Although it is little-known to the general populace that diesel engines can be run on vegetable oils, this knowledge is not new. In the 1890s, Rudolf Diesel concluded that any material that was injectable and would ignite at the temperatures generated by compressing air could serve as fuel for his engine.

During World War II this knowledge was put to use. When Japan was cut off from petroleum supplies, the **65,000** ton *Yamoto,* the largest and most powerful battleship of its time, used edible, refined soybean oil as bunker fuel. Japanese forces occupying the Philippines and Allied troops trapped in northern Burma used coconut oil for fueling diesel trucks and generators.

Since then, that experience has been largely forgotten. But in the U. S., South Africa, Australia, Brazil, Canada, Thailand, Japan, and perhaps elsewhere, individual researchers are rediscovering that diesel tractors, buses, and stationary engines can operate when fueled with sunflower, soybean, peanut, rapeseed, and other vegetable oils.

The experiences are usually solitary and most involve only very short running times. The practical potential of vegetable oils as commercial diesel fuel substitutes is therefore uncertain. But, at least in the short run, they work.

Of all the research laboratories testing diesel engines fueled by vegetable oils, the South African government's Division of Agricultural Engineering has the most experience. At its laboratory near Johannesburg it is running 10 tractors on sunflower oil. Fiat, International Harvester, John Deere, Landini, Massey Ferguson, and Ford tractors are being used, With two exceptions the tractors started satisfactorily on undiluted sunflower oil, All operated normally, delivered almost full power, and had virtually the same fuel consumption as on diesel fuel. A Ford 7000 tractor has run trouble-free for almost 1,400 hours of operation on a farm using a blend of 20 percent sunflower oil and 80 percent diesel fuel. At the end of this time it was found that deposits in the combustion chamber, cylinders, and piston ring grooves were no worse than those formed burning normal operation on diesel fuel. On the other hand, carbon deposits on the injector nozzles were worse and contributed to an eventual 4 percent power loss and serious gumming of the crankcase oil.

The rapid compression of fuel and air in the cylinder of diesel engines generates enough heat to ignite the mixture and power the engine. Unlike a gasoline engine, no spark is needed. Injecting the fuel into the combustion chamber is the most crucial step in a diesel engine. The fuel must be forced in against the pressure of the compressed air and to make this doubly difficult, the fuel has to be in the form of mist. If not atomized, the fuel burns slowly and unevenly, reducing engine efficiency, raising unburned pollutants in the exhaust and the lubricating system, and even forming deposits of solid carbon in the engine itself.

Vegetable oils are more viscous and less easily atomized than diesel fuel and are therefore more difficult to inject successfully. This is probably why the injector tips suffered build-ups of carbon. Coking and the resulting incomplete combustion diluted the lubricating oil and gummed it up because vegetable oils will polymerize when they are hot and next to metal.

The South African engineers, however, have found a way that seems to avoid these difficulties, They slightly modify the sunflower oil in chemical reactions using small amounts of ethanol or methanol. The resulting ethyl or methyl esters derived from sunflower oil caused much less coking than diesel fuel itself. Furthermore, they produced much less exhaust smoke, and the engine ran quieter so that the characteristic diesel knock was less audible, And, against all expectations, the engine gave more power with the new fuel than with diesel fuel. Thus tractors were running on a renewable fuel grown by farmers and achieving better results than on diesel fuel, Much yet remains to be done to test the widespread applicability of these results, but it is a line of research that is bright with promise,

CONCLUSION

Development specialists usually promote resources and technologies that are familiar to their own lives. Most agronomists, foresters, animal scientists, and nutritionists know little about the wealth of plants and animals to be found in the developing world. They all but ignore the significance poor people's crops, leguminous trees, and animal resources such as snails, guinea pigs, and butterflies. Instead they recommend and sponsor the introduction of species that are foreign and unconnected to the lives of those they want to help.

This paper identifies just a few exciting underexploited resources for developing country agriculture. Detailed information on them and many others can be found in the following National Academy of Sciences reports (all of which are available without charge from the Commission on International Relations, JH 215, National Academy of Sciences, 2101 Constitution Avenue, N. W., Washington, D.C. 20418):

- *The Winged Bean: A High Protein Crop for the Tropics*
- *Leucaena: Promising Forage and Tree Crop for the Tropics Underexploited Tropical Plants With Promising Economic Value*
- *Tropical Legumes: Resources for the Future*
- *Guayule: An Alternative Source of Natural Rubber*
- *Making Aquatic Weeds Useful: Some Perspectives for Developing Countries*
- *Firewood Crops: Bush and Tree Species for Energy Production*