

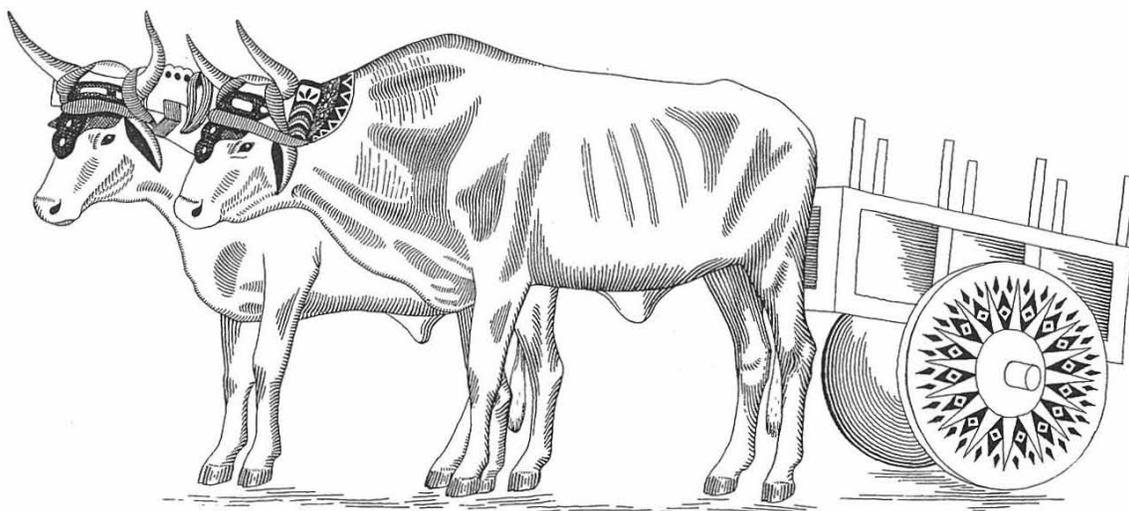
Land and
its Use

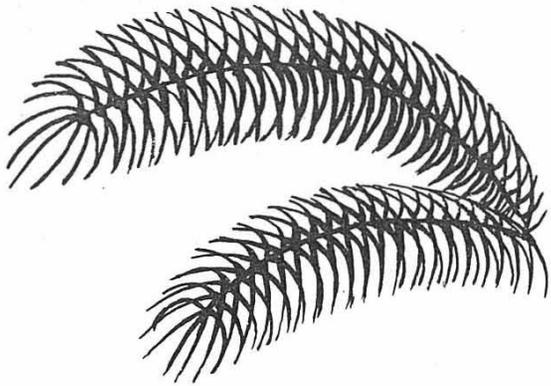


Costa Rica

The superiority of the bleak north to tropical regions, however is only in their social aspect, for I hold to the opinion that, although humanity can reach an advanced state of culture only by battling with the inclemencies of nature in high latitudes, it is under the equator alone that the perfect race of the future will attain to complete fruition of man's beautiful heritage, the earth.

— Henry W. Bates
A Naturalist on the Rivers Amazon
(circa 1850)





A Thumbnail History

Nine of us from the Cape Cod farm spent two months in Costa Rica this winter. It is a particularly appealing place for people from Massachusetts to spend February and March, but the articles that follow will indicate that it was not only a glorious holiday, but also a chance to test our ideas against new parameters and to learn the problems and needs of climates and cultures other than our own.

Both Bill McLarney and John Todd had been in Costa Rica before as readers of Newsletter No. 1 will probably remember. They knew of the scope for New Alchemy's approaches in the areas of both land restoration and protein deficiency. This year we saw a fair amount of the country and came to appreciate something of its problems and uniqueness. The articles that follow make no pretense of being comprehensive. The first is a thumbnail sketch for people who know that Costa Rica is probably in Central America but are rather foggy about anything beyond that. The second is a kaleidoscopic verbal slide show which describes something of what we saw and felt as we travelled. John Todd's essays discuss tropical agriculture in terms of the threats that current practices pose to the land and of the possibilities of adopting restorative ideas and methods before damage becomes irreparable.

Costa Rica is the second smallest country in Central America with a population of 1,800,000 and an area of 19,575 square miles, and is located between Nicaragua and Panama. Spain's interest in Costa Rica was first aroused by Columbus who landed at Puerto Limon in 1502 on his fourth and final voyage to the new world. He was met by Indians of the Carib tribe who were wearing golden ornaments which at once, of course, piqued the attention of the Spaniards, and gave the country its name. Columbus was followed by successive explorers but none found enough in the way of the desired gold or other resources to warrant large scale exploitation. Apart from Roman Catholic missionaries to the Indians, by far the majority of Spanish colonists in Costa Rica came and remained as settlers. As the Indians they encountered upon their arrival were

either killed in their fierce resistance to having their territories encroached upon, died from their exposure to white men's diseases or retreated to remote areas, there were few indigenous people to be subjugated into a serving class. The pattern of the country then was formed early and has basically remained one of small, largely self-sufficient landholders, giving it a comparatively homogeneous social structure.

Until almost the middle of the 18th century, Costa Rica was an outpost; a small, isolated, little known and extremely poor colony of Spain. The people, who remained mainly pure-blooded Spanish, labored long and hard on their land to stay alive and were often too poor to have suitable clothes to go to church. They had little time or money for education or culture and had neither a subservient nor dominant social class to influence their way of life.

Although little of the turmoil caused by the waves of nationalism and revolution of the late 18th and early 19th centuries was felt in Costa Rica, when Costa Ricans learned in October 1821 that Guatemala had declared its independence from Spain, they voted on November 1, 1821 to do so as well. No opposition from Spain was encountered. Political independence brought closer ties with other Central American countries as they tried to forge the United Provinces of Central America which functioned sporadically until 1848.

In 1797 the cultivation of coffee was introduced. By 1829 it was the country's major export. This rather unexpected boom brought other changes. Coffee was a highly marketable rather than subsistence crop and led within surprisingly few years to the establishment of larger plantations and to increasing prosperity for the growers. With the beginnings of even a modest amount of wealth and leisure came the evolution of some cultural life and inevitably the dominance of political affairs by a few wealthy families. A railway was built, linking the coffee producing areas of the central part of the country with Puerto Limon on the Caribbean coast and facilitating greater communication both within the country and with the world beyond. The railway was built by an American under contract to the Costa

Rican government. To build it he brought in large numbers of Jamaicans whose descendants remain in Limon Province and constitute the major significant racial and cultural minority in the country. By providing access to a port from inland areas, the railway made possible the establishment of banana plantations. Bananas have become second only to coffee as an export.

In the hundred and fifty years since Independence and the introduction of coffee, the life of the Republic has become considerably more complex. The government tourist agency, El Instituto Costarricense de Turismo, declares in its circular that "the country has become famous for the hospitality of its people, its stability, its high cultural level and widespread public education". It is rather a smug assertion, but characteristic of tourist circulars, and there certainly is some justification for what is said. As Latin American countries go, it has been remarkably stable. It cultivates the image of the "Switzerland of the Americas", a bastion of democracy and tranquillity amidst the political turmoil and violence of its neighbors.

The form of government is democratic. Its present form is based on a constitution adopted in 1949, after a brief revolution. Suffrage is universal and compulsory. The army was abolished for the second time in the country's history to prevent seizure of government control by the military. The Communist party was outlawed but has since been reinstated. Order is maintained by the Civil Guard and by the Town and Village Police.

There are many political parties but at the present the P. L. N. (the Partido Liberacion Nacional) is in power and is the most popular, usually requiring the mustering of several others into a coalition to oppose it. The P. L. N. first gained prominence in 1948 under the leadership of José Figueres as representing the growing middle class and opposing the strange bedfellows of the Communists and the wealthy upper class. Figueres was elected president for a second time in 1970. The next election is in February 1974 and Costa Ricans are already actively campaigning. Bright banners are flying and posters are being displayed everywhere.

Costa Ricans take great pride in their educational system. Education is free and compulsory. The literacy rate is considerably higher than that of other Latin American countries, and the University of Costa Rica is well-established. Yet one critic has said that the average Costa Rican remains in school only 3.5 years, just long enough

to be firmly persuaded that he is unusually blessed in having been born a free citizen of a modern and progressive democracy.

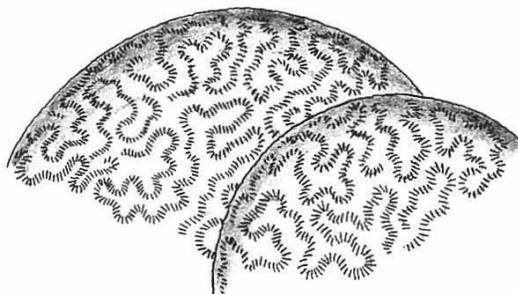
Regrettably, I have to differ with the Instituto de Turismo with regard to the "high cultural level". We were struck by the conspicuous lack of evidence of an indigenous culture, particularly in the forms of architecture or crafts which would be the most immediately apparent to an outsider. With the exception of the native ox cart and the ancient Indian gold work and pottery, there is little that is unique or memorable, and we could not account for this until we learned of the centuries of struggle merely for subsistence.

Costa Ricans are with few exceptions almost entirely Roman Catholic, although many are only nominally so. The Church receives financial support from the government, and although it is denied political activity, its influence is strong. Apparently governmental support is given in the hope that the Church will buffer the temptation of Communism for the people.

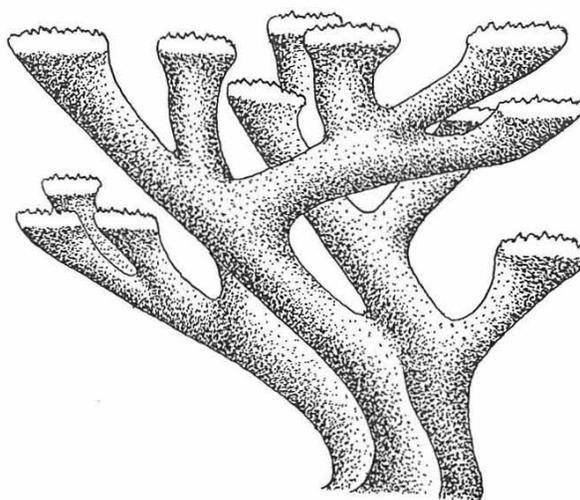
Again El Instituto de Turismo.... "However the country is fast becoming industrialized thanks to the abundance of raw material and cheap power, to the skill of its laborers, to its ideal location in relation to important markets, to its ready means of communication and the substantial incentives it offers for establishing industries with local or foreign capital." With such official policy it will surprise no one to learn that foreign investors have responded with predictable and characteristic alacrity and names like MacDonalds, Honda, Texaco, Volvo, Peter Pan and endless others proliferate.

The most dismaying aspect of this to a North American, at least to one that is not an admirer of the dominant culture, is that in their pride in being "progressive" and "modern", in their anxiety to acquire consumer goods and a higher standard of living, Costa Ricans display an eagerness, even naiveté, which is almost frightening. It becomes even more ominous when one of the names mentioned in connection with many developmental schemes is that of Robert Vesco, a prominent participant in the Watergate affair. Rumors are many and elusive about Mr. Vesco's activities. His private 707 at the airport bears witness to his interest in the country. One cannot help but see the signs of exploitation everywhere, and wonder how a people can so willingly let their exquisite country drop, like a ripe plum, into the hands of "developers".

— Nancy Todd



Travel Impressions



MESETA CENTRAL

We flew from the States to San José, the capital of Costa Rica. San José is geographically as well as politically and socially the center of the country. It is almost mid-way between the Atlantic and Pacific, on a high plateau called the Meseta Central which has an altitude that ranges between 3000 and 5000 feet, and a climate that is close to perfection. Many days in the dry season are warm and sunny but not humid, others bring rushing winds or tumbling clouds. The nights are cool and starry. In the rainy season there are bright mornings and wet afternoons, which seems an admirably well-regulated system, although when we left Costa Rica it was in the grip of the worst drought in fifty years. Water and electricity were severely rationed, and everyone was anxious for the onset of the rainy season.

Ringling the Meseta Central are ranges of mountains and volcanoes, some extinct and others not. The best known and most active is Irazu which erupted in 1963 causing considerable devastation from falling ash. Now it rumbles steadily but quietly and is a great tourist attraction.

One of our favorite places in the Meseta Central was the farm of New Alchemy Associate Peter Scherman. His farm is on Volcan Barba, outside the town of Heredia. It would be difficult to conceive of a more beautiful place and it is a rather happy thought that it is in the hands of someone who will never abuse it but only try to understand and care for it.

Late one afternoon, I could think of nothing nicer to do but climb one of the hills and sit, just looking. This is what it was like.

The wind blows gently. The sun burns a hot patch on my right thigh and my cheek. It is moving lower to set over the Pacific in an hour or so. It casts long shadows of me and of the young guava trees around me. The shade is deep and dark under the row of cypress trees behind. Over my left shoulder is a high hill, much higher than this, one of the shoulders of Volcan Barba. It is a patchwork of woods, cypress, and grazed fields. The hillside is cut by streams, lined with columns of virgin forest.

On the flank of the hill opposite are fields of sugar cane, banana and coffee. Through a valley on the plain below, I can see San José and on to the high mountains beyond. The city is under cloud but lit by the slanting rays of the late afternoon sun, so that the buildings are like toys - tiny, white and distinct. On the right, in the foreground, is a continuation of cultivated fields. From here, the fields of sugar cane look like carefully cropped lawns. Farther away, the hills merge into mountains, and beyond the mountains, there is a glimmer that is the sea.

SARAPIQUI

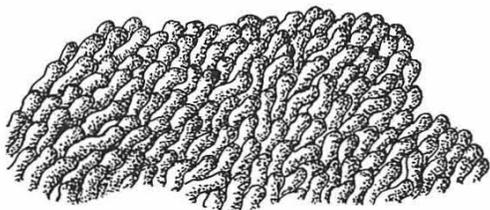
Most roads in Costa Rica take San José as their focal point, and so traveling is usually done from San José outward, like following the spokes of a wheel. Our first spoke led over the mountains almost due north to Sarapiquí.

As the mountains surrounding the central plateau taper to hills, they become, through some quirk of their geological past, strangely rounded yet steep-sided, looking like so many irregularly-sized eggs up-ended in a container. Some of the hills are wooded but many have been cut and turned over to cattle. The hills flatten gradually to a plain that extends steamy, rolling and green to the Caribbean.



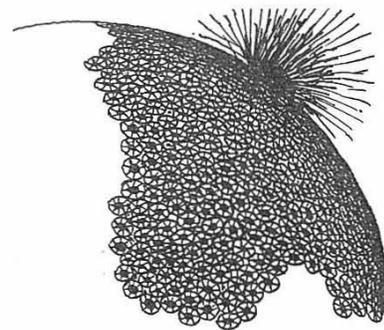
It is the humidity and the plants of Sarapiquí that one notices most immediately. Although much of the jungle is second growth, it remains lush and dense. A few giant trees have been left standing and they are magnificent whole worlds in themselves with looping, trailing lianas, and countless epiphytes of every description from fern to glossy philodendron to orchid. Wasp and oropendula nests swing from the branches, lizards flash along the trunk, and birds are a continuous moving presence. Climbing one of the hills at dusk, the landscape has a quality of a painting by Turner, as a cloud drifting down from the mountains wraps the distant hills in mist, fills the valley, and filters the sunset.

In Sarapiquí, as in every other part of Costa Rica we visited, the rivers are a constant source of pleasure. It is a law that the trees bordering the rivers must not be cut, and this law unlike others, equally wise with regard to the preservation of their country, Costa Ricans have chosen to observe. So, always under immense gnarled trees, the rivers flow over sand or rocks, slowing and eddying to form pools or rushing along in swirls or rapids, sometimes just drifting. The intense tropical light and nearly vertical sun are shaded and softened. There are secret, shadowy places reflected in the water. Used as we are to the inaccessibility of our polluted rivers, we loved the freedom of finding a cool river and tumbling in, the children looking like small flowers borne along on a tropical stream.



VALLE DEL GENERAL

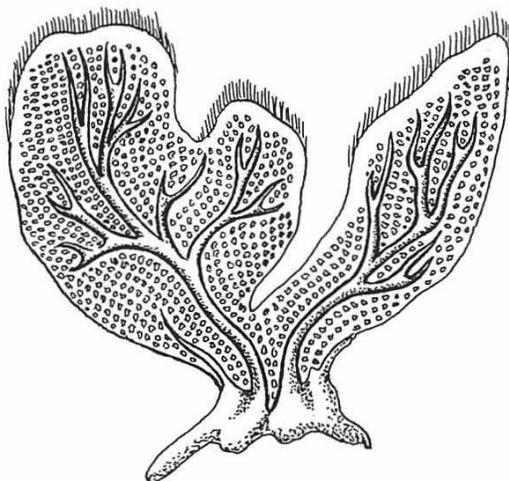
South across the mountains from San José, over the Cerro de la Muerte, the Hill of Death, in the Valley del General lies San Isidro, a bustling little place with the air of a frontier town. The drive from there to the Pacific over now familiar humpy hills is almost perpendicular most of the time, with some sort of apex midway that has the general effect of reversing one's angle of travel. It is one of the bumpiest drives in a country of very creditable bumps and one of the most beautiful. The sky is brilliant, the sun searing and the land still green, although showing signs of drying under the strain of supporting cattle. Much of the forest has been cut for pasture, leaving the way clear for erosion and leaching of the soil. From some of the hilltops there are dizzying views of land and sea and sky, the breath-taking sweeps one would usually see only from a plane.



We came to the sea at Dominical. Following the pattern of much of the continent, the Pacific coast is drier and brighter than the Atlantic, the light and heat being at times almost unbearably strong, even the water is hot. The sea and sky there are brilliant blue, the land spring-green, the beach curves toward the distance shimmering with heat. Coconut palms line the beach. Between them were smaller leguminous trees blossoming with pale pink flowers and sea grape which were losing leaves and changing color so the fallen leaves of red and yellow lay scattered on the beach and floating in the water like ghosts of northern spring and autumn side by side.

The beach was unbelievably empty. A few families were camped under the palms in makeshift tents. Our other beach companions were chickens, lizards, cows and an occasional rooting pig. They were all quiet and well-mannered and didn't litter the beach with beer cans. The most astonishing creatures we saw here were great four-foot iguana called chicken of the jungle. Defying the usual stereotype of the reptile as swift-moving and graceful, this unfortunate lizard is rather stout and crashes through the underbrush with an ungainly waddle.

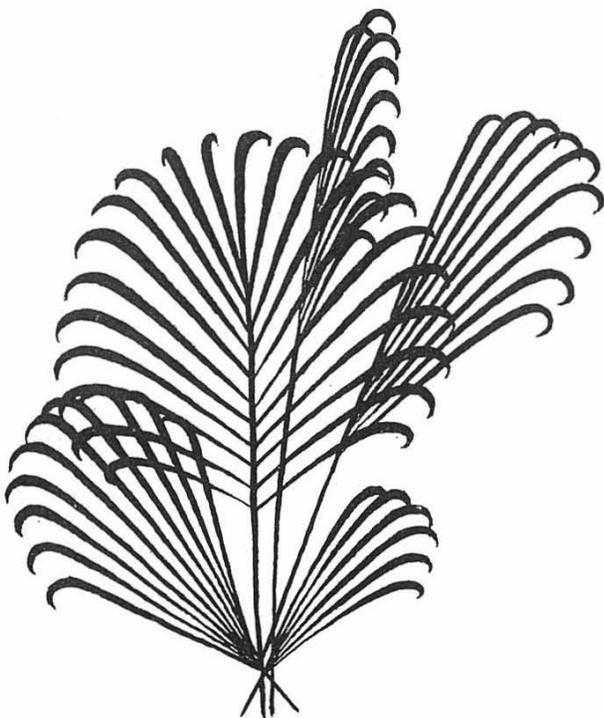
Occasionally some of the local people, who usually live on small coastal farms, would gallop on horseback along the beach. One woman trotted by us grasping reins and an umbrella for shade in one hand, her other arm cradling an infant, who slept blissfully on his real rocking horse.



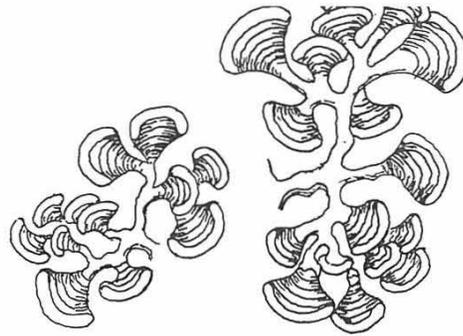
GUANACASTE

The province of Guanacaste is in the northwest, just below the Nicaraguan border and was in fact once a part of Nicaragua. It is cattle country, hot, dry and dusty. We had heard it said several times in other parts of the country that Guanacaste is becoming a desert. Someone reported that the naturalist, Alexander Skutch, had visited there recently and had been horrified at the changes in the last thirty years. Now apparently it takes four and one-half manazanas (8 acres) to support one cow where it used to take only one. So we went off braced for a ravaged environment, and although most of the foreboding reports are true, fell in love.

The rolling tawny hills had a déjà vu quality for all of us, stirring half-forgotten memories of some other place or time. The wind blows constantly through this hot, golden land. The trees are immense with great spreading branches that are the only refuge from the continual sun. At that time some of the trees were blossoming with yellow, pale pink or rose flowers. At night the stars hang bright and low, just out of reach, beyond the branches of the trees. The sense of space and sky that



characterizes so much of the western side of the continent is part of Guanacaste, but there is there a quality of light, particularly at dawn and dusk that has a strange luminous clarity which is unique. Early one morning through the gap of our tent we could see a huge tree outlined against a pale yellow sky. It was alive with dark, moving shapes. Then came the strangled roar of a howler monkey and the day began with their outraged cries.

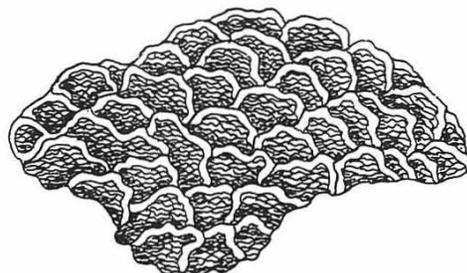


LIMON

Limon is the Atlantic or Caribbean province, extending from the Panamanian border north to Nicaragua. The largest city, Puerto Limon, is the country's major port. There are many old Spanish-style buildings, some with delicate iron work, that have a dilapidated elegance. The central plaza is splendid, like a lush, well-groomed jungle. The atmosphere of the city is the most intensely alive and active of any in Costa Rica. A large proportion of the population is black and most of them speak English as well as Spanish. The rest of the people are Costa Rican Spanish, with a handful of American tourists and a sprinkling of Chinese running restaurants and hotels. The general feeling is hip, gay and uninhibited. We saw people dancing and singing full-volume in the street. The music blaring from an appliance store was a kind of Spanish jazz rock, and one of the children said the music was better here because of the Blacks, which I'm sure was true.

From Puerto Limon we journeyed southward in stages by train, dug-out canoe, and bus to a village called Cahuita. It is a fishing village with several stores, two restaurants, a tiny hotel and poor but pretty houses. The people are mainly black, bilingual, friendly and independent. They are descended largely from the Jamaicans who were brought there to build the railroad. From Cahuita we jolted by truck to Puerto Vargas, our ultimate destination for this leg of the trip.

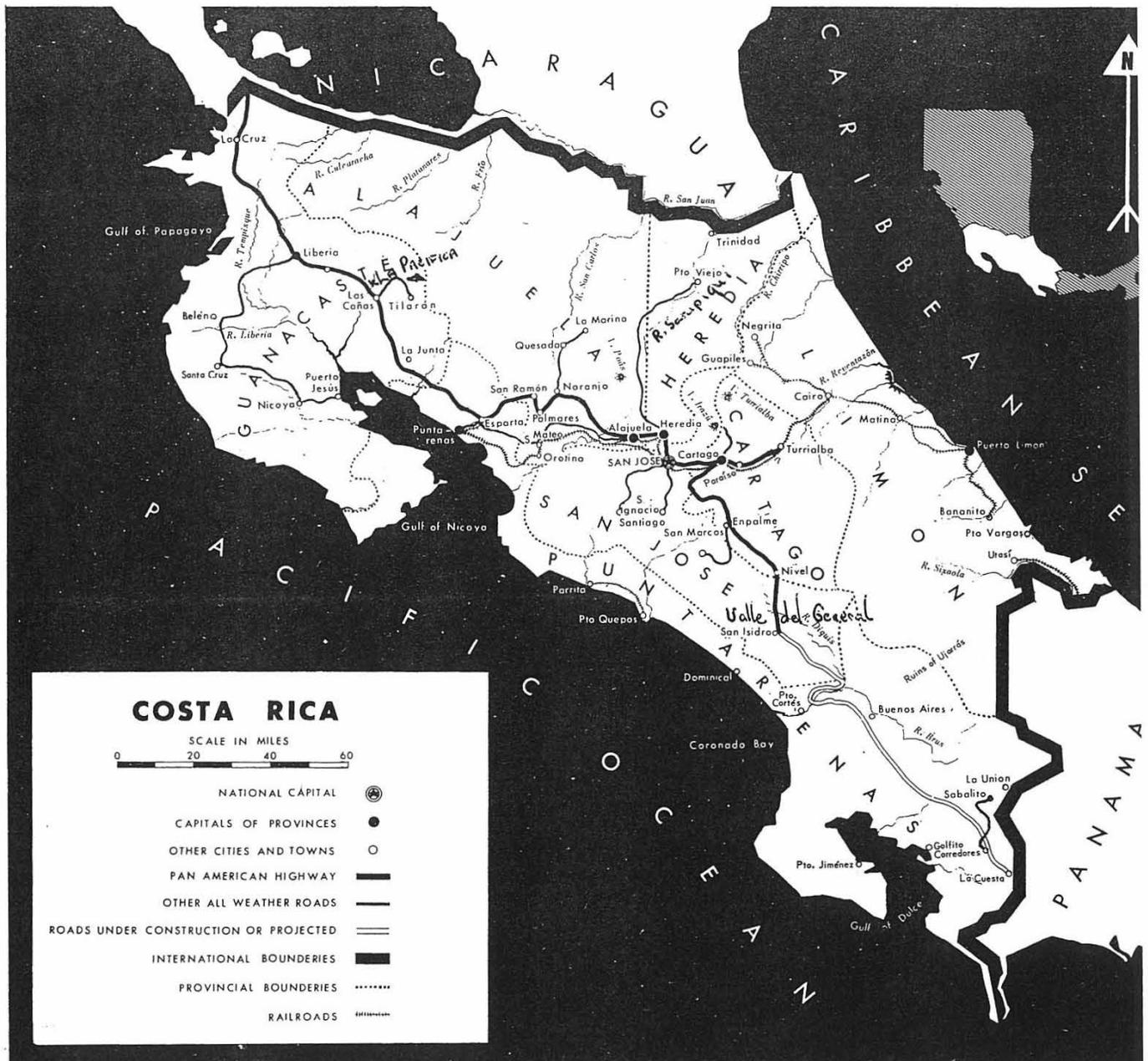
Puerto Vargas consists of one building on a magnificent beach that stretches as far as one can see, perhaps all the way to Panama. Inland are the Talamanca Mountains, where the 6000 or so Indians who have not been assimilated into the dominant culture have retreated. In the

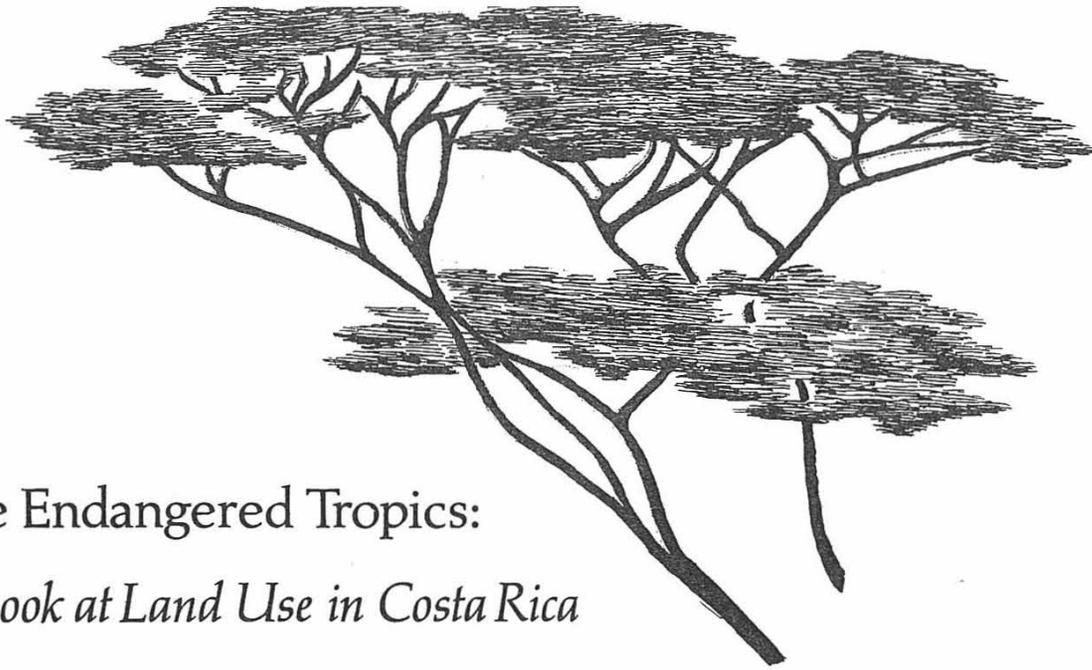


more remote highlands they are still isolated and reportedly hostile. The beach itself could be the archetypical tropical paradise, with a coral reef off-shore that has lobster in its crannies and technicolor fishes flashing by. Coconut palms in a wavering line mark the line between beach and jungle. One can sit on a fallen palm, feet dangling in the water, and see miles of unspoiled coast, or gaze seaward to the reef where the waves break and across the Caribbean beyond. Turning to the jungle above the flowers and shrubs, birds and butterflies dart, sun shafts through shade, monkeys swing and forage, a sloth clings to a vine, squirrels scuttle in the fallen leaves and occasionally a coconut thuds to the ground.

Rumors stir that scent of this lovely place has been caught by American developers. There will be "luxury hotels" one man told me glowingly, "like Miami - and restaurants, tourists, even a jet-port, they say"....

Although we were in the country for most of our time in Costa Rica, with fairly frequent stops in San José en route from one place to another, we did spend a little time in various towns and had some chance to get a feeling for them. Town life in Costa Rica still has a different quality to ours. It is noisy and busy, yet still seems less frantic and more personal. People linger in the streets and in little cafes called pulperias. In the evenings it seems everyone in the town comes to walk in the square, families with children, courting couples and groups of teenagers. Small boys wanting to shine shoes are always underfoot. People talk and laugh and watch each other. The children run and play. There is little feeling that, for these people, the mainstream of life has moved away from the small towns to the city. The pulse still beats in the lighted square, where boys and girls smile at each other and children drift off to sleep on their fathers' shoulders as they turn homeward.





The Endangered Tropics: *A Look at Land Use in Costa Rica*

The dynamic of the modern industrial society is gaining a toehold in the tropics and changes are taking place which will put tropical societies in a precarious state during the decades ahead. Costa Rica, an "advanced" modern nation, provides an excellent example of what can and will happen when the forces of industrial societies and their resource demands are unleashed upon a small, primarily agricultural nation. Change is occurring rapidly and Costa Rica's course may be towards a kind of corporate feudalism as insensitive to land as to peoples.

Daily events seem to symbolize what is taking place there: Robert Vesco, an international meddler in the politics and financial matters of nations par excellence, cavorts with many key citizens; lumbermen from the U. S. and Europe scan the remaining forests; huge air freights jet daily to Rome with their cargoes of Brahman cattle; the populace, in the main hooked on technological trivia, transistor radios and the like, believes consumption to be far more important than caring for its lands and protecting its heritage. In this last respect the attitudes of Costa Ricans are like "moderns" everywhere, but here the malaise takes on a more ominous aspect. Their consumption is reflected in a heavy imbalance in trade, which presumably leads to monetary and political favors afforded their creditors, mainly Americans. How much of their politics originate in Washington or in the board rooms of New York is difficult to tell, nevertheless, the likelihood of Costa Rican autonomy being in serious jeopardy is very real.

Costa Rica, a beautiful, bountiful land, may be stepping out on a razor's edge. It is not possible to lay the blame on any specific element present in the society,

whether it be consumerism, profiteering, short term perspective, or the insatiable needs of industrial nations for other peoples' plant, animal and mineral resources. All of these factors are involved. The processes are the same as those taking place in temperate societies. The fundamental difference is that Costa Rican environments and the communities they sustain are much more vulnerable, and options for the future are rapidly being reduced. I will return to this point.

One of the things I wanted to do during my last visit was to chronicle some of the changes taking place. Most of my information came from directly observing how Costa Ricans use their land, including the components of industrialized agriculture they have adopted. It was important for me to try to learn to what extent they are users of agricultural chemicals, including pesticides and herbicides, and to what extent their farming involved destructive monocultures. If roadside billboards are any indication of reality, biocides are big business with foreign corporations competing for title of most effective producers of killing substances. Anti-malaria campaigns of earlier years had created a marvelous psychological arena for poison peddlers. A common sign in rural areas, in the schools, public buildings and private houses reads simply "The spray man is your friend".

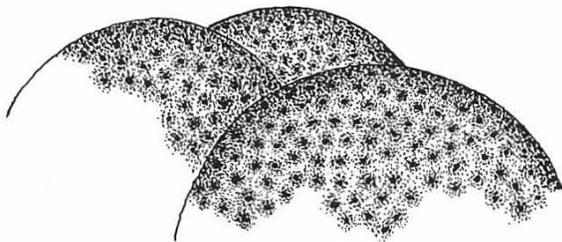
It was not possible for me to find specific facts on either the rates of change or the degree to which Costa Rican landscapes are taking a beating. I don't think this kind of information has been collected. There are some tangibles to grasp about the country; it has one of the world's highest growth rates. Imbalance of payments, deforestation and overgrazing are reflected in exports of lumber and cattle. There are, during the dry season,

water shortages and power blackouts. Fuel shortages are beginning to be considered normal. One trip had to be curtailed part way because we simply couldn't buy fuel in order to proceed.

At this point I want to introduce a bit of an apology... I do not know the country well. I spent this winter travelling throughout much of the countryside, but it was only my third visit to the country. My impressions are those of a farmer, naturalist-ecologist, with a deep interest in people and their use of the land. What I saw was a country of incredible beauty and great diversity that is changing rapidly. Out of my experience I have come to the conclusion that unless land restoration, along ecological lines, is embarked upon soon and local means are found to effect reconstruction, by the year 2000 Costa Rica will become irreversibly despoiled and her peoples reduced to a state of poverty. The country will be a desert in the west and a quagmire in the east. It will be unable to support its peoples. However, here and there in the wasteland of the western part of the country will be little islands of green.... the resort hamlets of rich Americans who already own much of the land along the Pacific coast. Their lush vegetation will be sustained by artificial and costly means such as desalination plants. The villas of the rich will be shaded and they will have water to drink. Apart from these cases of very dubious merit, the land around will be barren and depopulated.

I don't believe I am being overly dramatic. I obtained several conflicting figures on the extent to which deforestation has taken place. Some ran as high as 70% but this figure was not confirmed. Whatever it is, Guanacaste is basically deforested, the Valle del General is well on the way, the regions to the north and east have had much of their most highly valuable timber removed, and the pace is quickening as the value of lumber skyrockets. Massive deforestation in tropical climates, particularly in moist hot regions, leads to a tremendous drop in the carrying capacity of the land. In fact in a few localities the land has already been abandoned.

Except for scattered visionaries, few people are planting trees. Yet to overlook biological realities is a sure road to ruin for small tropical countries and, unless Costa Ricans take a unique stand and develop, in the very near future, a sense of stewardship their country will lose the ability to sustain itself. Not only will the beauty and the bounty go, but a very fine and humane people will suffer.



TRAVELS THROUGH THE LAND

Nancy Todd has described some of the splendor and feeling of travelling through Costa Rica. Its essences are very real and the land emanates a power that is felt even by people who are untuned to the earth around them.

GUANACASTE: THE NORTHWESTERN PART OF THE COUNTRY

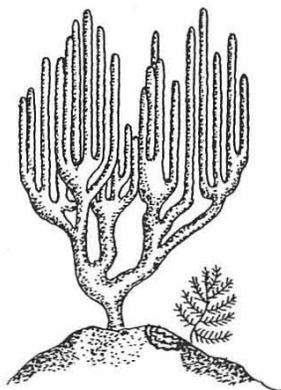
As recently as forty years ago, Guanacaste Province with its long and severe dry season combined with a comparatively rainy wet season still had large areas under forest (1). Since the second world war, as timber and cattle became increasingly valuable, landholders sacrificed almost all of the region's trees except those immediately adjoining the banks of streams. Then they planted pastures which are burned each year at the beginning of the dry season. Great profits were made in lumber and cattle but unfortunately the topsoils have not been able to stand up to the beating resulting from deforestation, heavy grazing and burning. Local ecosystems have lost much of their productivity as the soils, deprived of their humus, can no longer sustain much moisture during the rains. Flash floods are now considered "normal". During the dry seasons the scorching sun exposes the soils to temperatures that are harmful to the wide array of organisms normally present in fertile soils. One cattle rancher told us that in some parts of Guanacaste 4.5 manzanas (approximately 8 acres) is the bare minimum to support one cow.

This winter a drought more severe than normal hit the country. On March 22 I wrote in my diary: "The fall rains didn't come and the meagre grasses are not making it through the dry season. Only one of the African grasses seems to be holding up, but the half-starved animals don't seem to eat it. Off the road west of Cañas we saw dead cattle left where they fell. There was an almost total absence of soil in many places, only rubble and scattered drought-resistant plants. We were told at La Pacifica that it would be two more months before the rains came."

Cotton used to be another major crop but it too was the kind that can wreak havoc upon any environment. A few years ago it was a major crop, but in order to keep ahead of the pest populations characteristic of monocultures in hot climates the farmers were forced to spray parathion and other pesticides 20 to 30 times through the cotton growing season. Finally the point of no return was reached and the farmers were left with their cattle economy. A despoiled landscape supporting a cattle monoculture.

In a few years Guanacaste will be unable to support much more than cactus and sand unless reforestation, soil restoration and an agricultural diversity is introduced into the region. Already there are indications of depopulation taking place although this is not yet reflected in reduced land values. The value of land has remained

high, partly because North American ranchers are still buying land. Lyndon Johnson had a large ranch there and a number of other Texan cattlemen have followed him. High land values have created a state of unreality about the region: The beauty of its hills and mountains nestled close to the sea has attracted many well-to-do who are not dependent upon their ranches to earn a living. The social truth underlying the area may be reflected in the increasing numbers of poorer people away to the cities like San José. I heard that there was at least one area in Guanacaste where people were being forced to leave because they could no longer be supported by agriculture or lumbering. This does not have to happen. There are ways in which the process could be reversed but it will have to happen soon. Sadly enough, I see no likelihood of it happening on its own. Farms like La Pacifica, samples of intelligent and diverse land management, are scarcely emulated despite the signs of troubles ahead. Guanacaste is a cattle culture nearing the end of the line.... a desert in the making.



VALLE DEL GENERAL

Valle Del General, the area surrounding San Isidro, is more lush and rainier than Guanacaste and more recently settled. I did not get to know the area well but during our stay we travelled daily the road over the high hills west of San Isidro to the tiny coastal village of Dominical where I was studying several species of marine fishes. The region was comprised of mixed-crop, hillside farms galloping madly to change and catch up with Guanacaste as a leading cattle area. The land is much newer to monocrop grass farming and the forests have been removed only during the last few decades. Already there are indications that the exposed soils are very vulnerable: On the crests of the steep hills we observed cattle left to forage the coarsest grasses and toughest weeds so characteristic of spent soils.

But to talk of problems ahead there would be close to heresy. Money made in lumbering is being poured into cattle ranching. Ranchers from Guanacaste with an eye on the heavier rains and lush pastures are moving in. Electricity will reach the area next year as a large lake

is being constructed as a reservoir for hydro-electric power. There is talk of a huge beef processing complex and people are moving in in droves. There has been a 10-fold increase in population over the last thirty years and the process has only just begun. The government has built schools and a hospital and the region is acquiring a modern image.

Excitement is high, pure frontier, yet the boom will be short-lived. It was here that I felt the fragility of the land most strongly and at the same time I became most conscious of the land as the key to long term biological stability as well as social richness and health. This "other reality" has been chronicled by Alexander Skutch in his "A Naturalist in Costa Rica" (2). For the past forty years he has participated in the life of the valley, as well as pursued his scientific studies of the plants and bird life of the region. To read his chapter "Vicissitudes of a Valley" is to look deep into the eye of a storm that is brewing. There are the "hard facts". The list of wild animals that have gone, the birds that no longer inhabit the forests, the replacement of perennial crops including coffee on the steep hillsides with cattle. There are descriptions of deforestation on the most abrupt slopes replaced by pasture which is played out in a few short years.

A flight into night....all in a moment in time.

But these aren't the only agonies of the region. Dr. Skutch set out to preserve a small piece of forest on his farm. Not only were the game poached but some of his trees were stolen too. Tall palmettos and chonta palms containing the coveted hearts of palm were the special targets of thieves. In the end he was forced to hide his banana plantation deep in the woods in order to salvage his crop.

Skutch places the population explosion at the root of the crises facing Costa Rica and he may be right. However, it might be possible for the valley to support its present population if, and only if, economic realities were based upon strict ecological ones. At the present, the name of the game is multipronged rape; exploitation, deforestation, monocropping and overgrazing. The vision is limited to today - tomorrow is another matter.

Processes which take a century in temperate regions are acted out in a few years in this beautiful, vulnerable country. The needs of the original ecosystem have not been met. The thin soils are exposed to leaching, burning and the incredible heat of the sun. When the soils are played out a farmer must continue to burn the remaining vegetation in order to release enough minerals for new plant growth. Each time he does so there are more losses in the cycle and the reservoirs of precious nutrients are lost to the atmosphere and to the sea. The fertility of the region that was once locked up in its trees is almost gone. When will men learn that an area's destiny is tied to its soils. In the humid tropics this truth is magnified, yet it has failed to capture the imaginations of the people who live there.

SARAPIQUI: ATLANTIC TROPICAL WET FOREST

Sarapiqui, the region bordering the Rio Sarapiqui, has a special meaning for a number of New Alchemists. Bob Hunter, a scientist-farmer, has worked the land there for almost two decades on his farm, *Granjas Tropicales*. Bill McLarney was lured to the region by its rain forests, biological diversity and the intriguing fishes which are found in the streams flowing into the Caribbean. This past winter Bill and Bob Hunter began construction of the first of a series of fish ponds in order to test some of their ideas in tropical fish culture. It was in this region that New Alchemy attempted to buy an experimental farm, but we were outbid and no new sites have been found.

In many respects Sarapiqui has an air of raw frontier. Roads are being cut into the forests and equally quickly logs are being hauled out. The drive there is a primary experience in avoiding careening logging trucks with their cargoes of felled giants.

Sarapiqui is wet, as much as 160 inches a year fall on the region, mainly during the May-December rainy season. One is awed by the huge trees and forests which are disappearing. When the earth's tree mantle is finally removed over the next few years it is not likely that the land will support much in the way of human endeavor.

The future beyond tomorrow is not much on people's minds. Sarapiqui and the adjoining regions are in the midst of a boom. A few years ago when I first was introduced to the area, small farms were prevalent and there seemed to be some diversity of crops. But the scenario is changing. The region has been discovered and the forests are being turned into grass for cattle. Everybody is involved, small Costa Rican farmers, ranchers from all over, North American lumbermen and big time Gringo entrepreneurs. The area is relatively remote, yet New Alchemy when trying to acquire a piece of land for an ecological farming research center was outbid by a group that included the owner of a large U. S. grocery store chain.

The aim of landowners seems to be quite simple: log, raise beef for a few years until the land is exhausted and then pull out for greener pastures. It is the antithesis of an ethics of permanence.

A region which receives so much rain cannot cope with this kind of treatment for long. It needs a fair amount of forest to act as a sponge to prevent the soils from being washed into the sea. It is hard to comprehend the impact of the rains without feeling it. At Puerto Viejo, the lower farm at *Granjas Tropicales*, the river rises and falls over a range greater than twenty feet.

The area can only remain productive and support a human population if the farms there are primarily based upon a permanent or tree crop agriculture. But farms based upon tree crops are few and far between. The best example of a permanent agriculture is the farm *Granjas Tropicales*, where a great variety of trees and

vines are cultured: rubber (*Hevea brasiliensis*), cocoa (*Theobroma cacao*), pejibaye palm (*Guiljelma gasipaes*), citrus (*Citrus spp.*), guava (*Psidium guajava*), African oil palm (*Elaeis guineensis*), achiote (scientific name not known), Macadamia nut (*Macadamia ternifolia*), passion fruit (*Passiflora edulis*), bananas (*Musa spp.*), plantain (*Musa paradisiaca*), breadfruit (*Artocarpus communis*), black pepper (*Piper nigrum*) and the root crops, cassava =yuca or manioc (*Manihot utilissima*) and Malenga= dasheen or taro (*Colocasia esculenta*).

There are no doubt several other crops I have overlooked. Another important aspect of the farming at *Granjas Tropicales* is the variety of interplanting of crops. In some instances one crop is planted to help prepare the ground or to act as shade for a following crop which takes longer to mature. Certainly there are serious attempts to work with nature and where possible to apply basic principles of ecological succession which is the maturation through time of an ecosystem growing towards more stable and diverse states.

Yet *Granjas Tropicales* does not seem to be having any significant impact on all over farming methods in Sarapiqui. There are a number of reasons why this is so: the farm may be too big to be comprehensible to the average farmer. So much labor, machinery, capital and organization; so much knowledge of trees, soils, climate, and so forth is required to orchestrate the whole complex. In short it's easier and simpler to run a grass and cattle farm and the payoff comes much sooner. Nevertheless, the biological farm does support a fairly stable human community, a school and a store. Much of the labor is carried out under the shade canopy of trees except in the groves of black pepper and passion fruit. These more human values don't really seem to carry much weight with most Sarapiqui cattle men.

Granjas Tropicales is an island of sanity and diversity in the humid lowlands of Costa Rica, lowlands which are rapidly being overrun by herbaceous weeds as the shallow soils are exposed to the direct rays of the sun and to the pounding rains. But the time may be fast approaching when neighboring farms will be too far gone to emulate the more land-restorative approaches of Robert Hunter's tropical orchards.

There is a truism which needs articulation and expression in a variety of ways so that its meaning permeates into the consciousness of those who hope and would create societies within nature's framework. Despoilation need not be the norm in Costa Rica or in any other segment of the world. A few tropical peoples are wiser and their communities are sustained by a sophisticated swiddening gardening which I will outline later. They follow the patterns of nature closely and by doing so they are able to support populations as dense as those found in industrial societies, and they do this without degrading the forests or the places where they live. Their genius should be a guide to those of us desirous of shaping somewhat autonomous, local ecosystems which can restore somewhat abused lands. (3)

AN ECOLOGICAL PERSPECTIVE OF THE TROPICS

The negative views I have presented in describing Costa Rica have their roots not just in the observations that were made, but also were gleaned from tropical ecologists. As more is learned about tropical ecosystems and their strategies, it becomes increasingly possible to view the future by reading the present well. Tropical environments are extremely vulnerable.

Many tropical lands in Africa and Southern India have lost much of their ability to support human populations and a great diversity of plant and animal life. These historical examples were not regions exposed to the recent blight of advanced industrial nations which comb the world for other people's resources.

Exploitation drives environments and ecosystems back to simpler, more vulnerable states (4). This backwards shift is most prevalent in the more diverse and productive regions of the world, such as the tropical rainforests. Indigenous plants are destroyed for lumber to be replaced with one or a few crops. While the process leads to degradation in temperate regions (5) in the tropics the situation rapidly becomes extreme and precarious (6). It is not just the plants that are affected. Stressed environments may eliminate some of the most highly evolved animals by eliminating their niches, or by directly interfering with their normal social organization (7).

Plants in tropical monocultures have severe difficulties coping with pest organisms. Monocultures dictate that plants of the same varieties be close together making them easy targets for pests. In wild tropical environments one of the basic plant defenses against insects is a varied and diverse spacing with any given plant association. Most plants of the same type are strategically separated in space (8).

When agriculture is industrialized and mechanized and lands are planted to single crops, other biological stresses are introduced into the system. The relationship between beneficial insects and the pests they prey upon breaks down. Without a diversity of habitats, the beneficial insects are deprived of a suitable "home" and they can no longer keep pests from proliferating. The problem is compounded, in the humid tropics especially, because the farmer lacks dramatic changes in weather that would limit outbreaks of herbivorous insects. For the northern farmer winter aids in keeping harmful insects at bay.

There is also a much more rapid loss of soil fertility in the tropics. When forests are denuded and replaced with cash crops the soils (the fertile zone is often less than 2" in depth in the first place) are washed away in very short order. Dr. Janzen, a tropical ecologist, has explained the problem well (6).

"When tropical vegetation is cleared, high soil temperatures and rainfall lead to an almost immediate removal of inorganic nutrients released from the dead plants. At best the remedy of fertilizers, intelligent methods of

clearing and promotion of microrhizal associations makes the new field an adequate substitute for growing crops. It does not guarantee a crop sufficient to compensate for the total cost of its production."

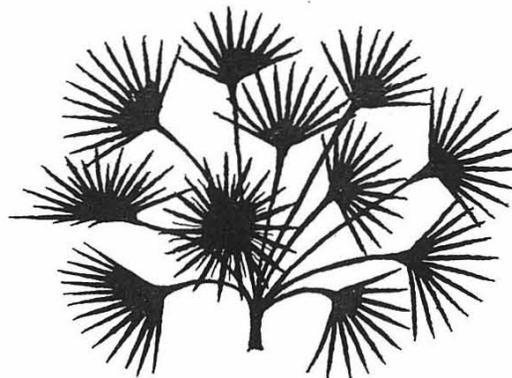
He then goes on to state that after 1-3 years the carrying capacity of tropical fields declines drastically and more fertilizer only aggravates the problem.

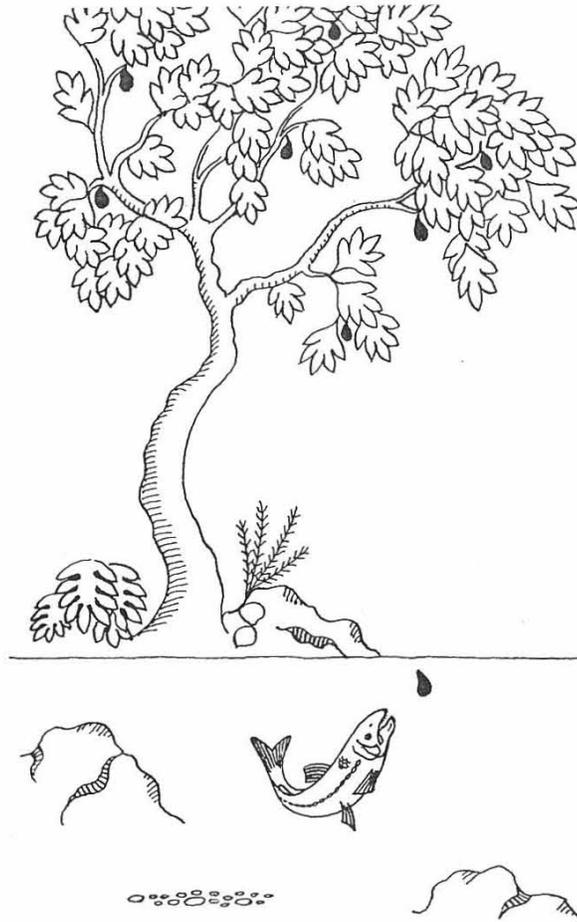
Tropical monocrop farms also have to cope with the fact that weed problems are much increased in tropical fields. The weeds, unlike the crops cultivated commercially, have an intrinsic ability to repel crop pests because they are able to produce poisons or defensive chemicals like strychnine in their tissues which keep pests from devouring them. Shade, created by canopies of the trees, is a major check against weed growth in the tropics. However, it is removed when the forests are destroyed.

Pests, weeds and problems of soil's fertility are greatly exaggerated in the tropics. Further the chances of biological controls like those being developed against temperate region pests are unlikely to work in large tropical monocultures because of the greater diversity of response strategies open to troublesome insects (6). This host of problems has been combated by the farmers and ranchers in recent years by the use of insane amounts of pesticides, herbicides and fertilizers.... a practice which mainly benefits foreign manufacturers far removed from the mounting problems they are creating. Heavy poisoning of tropical landscapes will, in the end, destroy most of their ability to restore themselves.

On first viewing, the present situation seems hopeless and worsening with no alternatives on the horizon. But a deeper probing suggests that it might still be possible to harness some of the productivity of the tropics so that civilized societies might be sustained in equatorial regions. I must add that I am making this statement cautiously knowing that mankind is under terrible pressure to recapture enough wisdom to alter the course of a failing planet.

Tropical realities are two-edged.... there is the abyss which we have covered, but at the same time there are beacons which light up on the other side. If we work close to and with nature some incredible potentialities rise up to challenge us and guide us.





Restoration and Reconstruction in Costa Rica: *Some Possibilities*

*“Build the old waste places.....
raise up the foundations of many
generations.....
be called, The repairer of the breach,
The restorer of paths to dwell in”
— (Isaiah 58:12)*

JOSÉ ARIAS RODRIGUEZ A STEWARD OF THE EARTH

I have often pondered why good farms like *La Pacifica* and *Granjas Tropicales* have had relatively little influence in Costa Rica, whereas the impact of Louis Bromfield’s Malabar Farm has reached into the far corners of the earth. Communication is part of the answer, but then why does one man try and reach outward to share his experiences and failures?

To answer this question in Costa Rican terms is difficult. The intractability of the cattle culture is part of the explanation, but certainly not all of it. I did not find an active program at the two large commercial farms to disseminate their information, improved varieties of plants, expertise or tactics into the larger Costa Rican agricultural community around them. Both are “foreign” farms

(one Swiss and the other American) and there may be a calculated desire to maintain a low profile in their adopted country. They are also first and foremost businesses with the primary goal of earning profits, and profits are often tied to the relative market scarcity of the crops they sell. The competitive-exclusion principle may tend to keep new and more successful ways of farming from spreading outward. There is also the very real possibility that the people running the farms are just too busy to have time to develop cooperative programs with their neighbors. Whatever the explanation.... and I suspect all these factors are involved, the word is not getting out and these excellent farms remain oases in an increasingly blighted landscape.

However, I met an incredible man, José Arias Rodríguez, who symbolizes for me what an earth steward

must mean if there is to be any hope for tomorrow. Don José crafts landscapes which restore and which are supportive through his trees. He is primarily guided by a humanitarian desire to make the earth a responsive mother for his countrymen. An old man now, he works with a few assistants in his nursery and orchards struggling hard so that fine trees will be available to those who understand the full meaning and potential of tree crops. He is a writer so that his ideas may have wings. Eagerly he spreads the details of all that he has learned so that others can follow. His latest book entitled "Fruticultura Tropical" is written in Spanish and is a sound and comprehensible guide to culturing trees in the tropics (9).

Like most men of vision Don José seems to have reached backward to pioneers of earlier times for inspiration and direction. He is a staunch disciple of Sir Albert Howard. One immediately notices the compost heaps throughout the orchard and he explained that in the tropics composting becomes critical to the sustained success of tree crops. For some forty years he has been breeding and raising trees and one new variety of citrus (the Rio Segundo mandarin) was created on his tiny farm. To walk through the farm was a profound experience for me. Don José talking in his personal rage against the destruction of the countryside of Costa Rica. Juxtaposed against his vital anger and desire to right wrongs was his nursery with thousands of tiny trees spread amongst the orchard. I could feel his humor when he saw me gaping at a bearing apple tree growing next to an orange ripe with fruit.

Several large trees in the middle of the garden were archetypes of the wisdom of his mission to reforest the land partially with a diversity of food trees. Standing out most prominently were two mango trees (*Mangifera indica*) which he had planted forty years ago. At their bases were compost heaps which he explained were the basis for the health and incredible productivity of the trees. Because of their health he rarely has to spray them, while other mango growers spray weekly against insects, especially the Mediterranean fruit fly and against fungus which attacks during the long ripening period of the fruits.

As he talked about the trees I attempted some crude calculations on just what those trees might represent in economic and ultimately social terms. Mangos, like avocados, are a valuable crop in Costa Rica, even at their source. His two large trees combined produce approximately 10,000 mangos a year. The labor involved in caring for them in a diverse orchard is not great, yet their value is high. Properly marketed, the fruits of the two big trees like the ones in the garden might represent a decent annual income for a relatively self-sufficient farm family in Costa Rica. I began to see the potential of Señor Arias and his trees. Fortunately for Costa Rica, some people are listening to him and his young trees are in great demand. The ideals that he stands for are becoming appreciated and young American organic farm-

ers in Costa Rica visit him frequently for his skills and trees. The tiny farm is becoming a minor mecca. While we were still in the country, a major newspaper sympathetically described his efforts to articulate and promote a land ethic for Costa Rica.

Restoration in Guanacaste Province: *Prospects for Arid Lands*

The great contrast in the climate of Guanacaste plays havoc on the land once it has been deforested. The climate naturally varies from torrential rains during the wet season to weather that is blisteringly hot and arid during the long dry season.

Since Guanacaste was deforested, flash floods, extremely strong winds and beating sun have resulted in the loss of the basic fertility of the parched soils. In order to restore this region it will be necessary to stabilize some of the impact of the extreme oscillations by tempering the winds, arresting the flash floods near their sources and returning the nutrients to the soils. Much of the area will need to be replanted to trees.

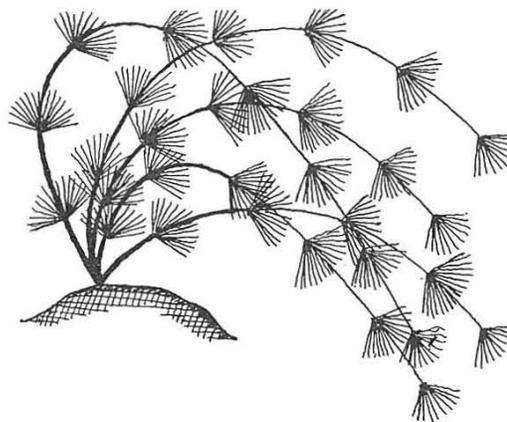
This is not an impossible challenge. A restoration scheme such as I am proposing would work best at the basic social unit, namely the individual farm. Further, a shift to a form of farming derived from ecological strategies could evolve out of existing cattle operations and there would be a place for cattle on the farms of the future. However, they would be one component out of many and they would not dominate the new farms either ecologically or economically as the farms are developed towards a more mature, stable state. The total carrying capacity of the lands would be greatly increased. Despite the diminution of the relative status of the cow on the ecological farms, in the future each individual farm could possibly sustain comparable numbers to those presently found there.

The strategy for restoration I am proposing can be briefly introduced as follows: The extreme oscillations in availability of water and the flooding could be controlled by terraced wadis, small dams and large ponds fitted to the local topography. In this way water and soils normally lost to the area would be retained. Recently discovered biological techniques may make it possible to construct ponds that will hold water even in porous soils. The ponds, enriched by animal manures, could be developed into extremely productive polyculture fish-rearing systems and the highly fertile pond water, in turn, could be released to tree crops and pastures during the dry season either through wind pumps or via ditches and aqueducts. The pond cycle can be very productive and is the key first step in restoring productive regions in arid zones. The ponds might not only permit the growth of large amounts of fishes, but pond water could also act as an important soil improvement technique by fertilizing as well as irrigating the crops. At least in the early stages this might be a critical stage in successful biological farming.

But this is not the whole task. The powerful winds which during the dry season dehydrate and blow away the top soils will need to be ameliorated by reforestation. On each farm the periphery and the hill tops should be permitted to return to wild forests which will break the winds and provide a diverse biological base. Towards the interior of the farm, meadows, pastures, ponds, tree crops and gardens should increasingly predominate. With careful planning to reduce winds in the interior, tree crops, like avocados, which now set fruit badly, or not at all, in Guanacaste because of high winds might be grown successfully. Interestingly, as the complexity of each farm increases the numbers of people needed to care for the land will grow proportionately and many people will probably decide to return from the cities to help tend the crops. Rural communities might be revived throughout the region.

Instead of beating sun and driving, dusty winds, there could be shade and moisture, and cooling breezes under the tree canopies. The rains could be enriched and stored for use during the dry season. New food chains will suggest themselves: Pond systems.... herbivorous, omnivorous and carnivorous fishes, freshwater shrimps, edible aquatic plants and perhaps even in some cases paddy rice could be grown. With water from the ponds, grasses, legumes, grains, fruit orchards, nut groves and high quality timber stands could be irrigated. Gardens, some situated in drained ponds, could be filled with a variety of vegetables, herbs and spices. Ducks, geese and chickens could be fed on the by-products and waste products. Cattle could be provided with shade and maintained on diverse pastures. As each cycle is increasingly linked over time, the productivity and self-sufficiency of each whole farm ecosystem should also climb. At the same time the cost of supporting individual farm residents would be reduced.

None of the tactics for land restoration that I am recommending be tried in Guanacaste are unique in themselves. Rain water runoff and control has been perfected in Israel, the pond cultures have been highly developed in parts of the Orient, and from Russia new information exists which could well permit water to be stored inexpensively. The importance of wild land reserves for a balanced agriculture is indicated from modern ecological studies, and the possible linkages between ponds and food crops from early New Alchemy investigations. The horticultural and forest sciences have a lot to contribute to our understanding of caring for food and timber crops. It is in the assembling of the components from very specialized disciplines into bountiful wholes that will take genius, patience and lots of plain, hard work. Here I can give only the broadest, most introductory outline of how it might be possible to make the land and its peoples flourish in Guanacaste. I intend my comments to be only the most general guides to the future.



RESTORATION BEGINS WITH THE CONTROL OF WATER AND THE BUILDING OF PONDS

The Control of Runoff

Several thousand years ago inhabitants of the Negev desert in Israel farmed using a sophisticated runoff agriculture. Villages, towns and commerce thrived because of their farming skills. How they managed to achieve the impossible and to grow in the desert fruits, wine grapes, grains, nuts and herbs described in the ancient manuscripts has remained a mystery for centuries.

The discovery of the lost desert farming techniques was made by a small group of scientists within the past few decades and their story chronicled in the book "The Negev: The Challenge of the Desert" is as incredible as it is important(10). My ideas for the control and use of runoff water in Guanacaste are primarily derived from them, and I urge those who are working in arid lands everywhere to study their book. Desert isolation forced the small band of scientists to be wholistic and basically ecological in their approaches to the land. The guiding hand of the ancients indicated that the solutions to the mysteries would come from an intimate association of the subtleties of desert ecosystems. For the desert dwellers, the simplest system they devised for capturing and using the brief and infrequent rains was through the terracing of wadis or channels of watercourses which are dry except during periods of rainfall. The low stone terraces slowed the course of the water, permitting it to sink downward into the soil. Equally important, the rich silts were prevented from being washed out of the area. Behind the terraces many of their crops, including grains, were sown.

Besides the wadis, on the more sophisticated farms with larger populations, the hillsides were terraced so that they would act as large catchments during flash floods. The terraces in these instances functioned as conduits and the whole hill provided water for irrigating bottom lands or for storage in cisterns. In the water-poor Negev desert the area of catchment to the area of cultivated fields was about 20:1. The movement of the silt in the runoff water to the crops must have played an important role in sustaining fertility.

Guanacaste is not the Negev by any stretch of imagination, nevertheless, the problems of gathering and directing water in large amounts during the rainy season are very similar. Water must be stored for the dry season and soil fertility must somehow be sustained. In order to do this water management should begin at the top of each microcatchment area just as is the case in the desert. One farm I looked at closely near Santa Cruz had steep upper slopes and the erosion had become so severe that only a few hundred feet from the hill tops the land was gutted with steep ravines. On this farm the only means of restoring it properly would be to build a series of tiny dams near the upper reaches and to lead the excess water into larger catchment areas in the fields below.

The crucial needs for water control are: 1. To avoid losing most of the water to the region; 2. To catch the soils being washed away close to their source; 3. To provide water for ponds which could be the key to restoration and soil enrichment in areas where rain is sparse or nonexistent for a large part of the year. Water storage in large ponds can provide a critical and novel approach to dry land restoration, especially in the tropics.

The Ponds

Rarely have ponds been used for water storage, silt entrapment, irrigation and aquaculture throughout the arid regions of the world for a very basic reason; namely that most desert and despoiled soils do not hold water well. In fact many such regions are characterized by stony and sandy soils. In the main Guanacaste soils appear to be ill-suited for water reservoirs. However, there may be a solution.

Very recently two Russian scientists may have found a possible answer to making porous soils impermeable to water through a study of the biological processes which take place in bogs. Bogs are ideal reservoirs because the stagnant water bottom soil complex called gley is impermeable. On the bog bottom the growth of anaerobic bacteria and the decay of plants without access to oxygen produces changes in the structure of the soil, and the ground becomes less porous. Apparently it turns greenish and blueish-grey and becomes a structureless, water-proof "plastic" mass.

The Russians were able to produce artificially bog conditions in the following way: "A layer of vegetation is spread by bulldozers on the soil surface. The best thing to use is dry vegetable matter rich in cellulose: straw, hay, weeds, potato and beet haulm, hemp waste, reed leaves and spoiled silage. The average is 6 or 8 pounds a square meter. The vegetation layer is then covered with a 6 to 8 inch protective layer of earth. Then the water is let in.

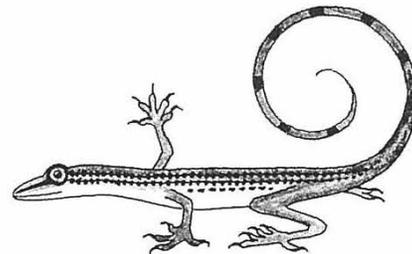
In this laminated screen, the vegetation serves as a source for the development and vital activity of anaerobic bacteria, which create the water-impermeable layer" (11).

Their discoveries, as yet little appreciated, could turn out to be one of the most beneficial findings of modern biology. They may have placed in our hands an incredible new tool that requires little in the way of capital. However, the "universality" of their findings are far from clear and it will be necessary to carry out research in Guanacaste to test if indigenous soils can be made impermeable. As yet there is no assurance that "bogs" can be established that will hold water through the dry season in Guanacaste.

Variations on the Russian experiments should be tried. One possible experiment might be to sow grasses densely on the empty dug ponds at the onset of the rains. About half way through the rainy season, when the grasses are well established, they could be mowed and the grasses be allowed to remain where they fall. Then the earth layer could be added, hopefully leaving enough time for the pond to be filled before the onset of the dry season. Several plantings and new earth layers might be required before the ponds are suitably sealed.

Ponds for the Rearing of Aquatic Animals

There is an incredible potential for the pond culture of fishes and other aquatic animals and plants in tropical climates. To overlook aquaculture would be tantamount to by-passing one of the most effective ways of coping with protein shortages in equatorial lands. In ponds it is possible to take advantage of three-dimensional space and the efficient ability of fishes and other animals to convert algae and microorganisms into edible and nutritionally valuable meat protein.



Oriental polyculturists (those who farm several species within a single pond) are able to raise as much as 8000 kg/ha (which is roughly equivalent in pounds per acre) utilizing relatively simple techniques and requiring only readily available feeds and fertilizers (12).

Certain Malaysian farms provide an interesting, more complex and productive variation on this theme. The pond becomes the key component on small self-sufficient fish-pig-plant farms; Ditches carry the manure from the pigs to the ponds. *Tilapia* and Chinese carp feed on the algae and small invertebrates which thrive in the fertile ponds. Aquatic vegetables (*Ipomoea repens*) are also grown with the fish and are harvested (hundreds of kilos daily) to feed the pigs. On a 4.4 hectare farm (approximately 10.5 acres) 3000 kgs (6600 lbs) of fish and

30,000 (66,000 lbs) of pig meat are produced annually (13). The pond in the Malaysian system provides many of the primary inputs into the farm.

The New Alchemists have begun a search for Latin American analogs to the Chinese and Malaysian systems. In South and Central America there exists a rich diversity of fishes which have been little explored for pond culture. This is particularly unfortunate, as the peoples of Central America enjoy eating fish when it is available.

Bill McLarney has recently embarked upon the lengthy task of studying Costa Rican fishes that might be suited to culturing and his first report is described in the Aquaculture section of this issue. In future issues of the JOURNAL he will continue to explore the ideas and describe the research which may lead to analogs of oriental pond cultures using native fishes in Latin America. Support for this work is being sought.

At this point I am going to propose a hypothetical polyculture scheme for Guanacaste that utilizes several native animals and one exotic already introduced for culture purposes into Costa Rica. A possible line-up is as follows: *Tilapia spp.* is the exotic in the system. Some species of *Tilapia* feed upon microscopic algae while others prefer pond plants, and all species are primarily herbivores feeding low on the food chain. The second genus of fishes that might be adaptable to pond culture is the omnivorous machaca (*Brycon sp.*) described by Bill McLarney.

Also there are catfish of the genus *Rhamdia spp.* which grow to edible size in the slower reaches of Guanacaste streams and they could well occupy a vacant niche in the polyculture ponds. Not to be overlooked is the freshwater shrimp (*Macrobrachium sp.*) which also grows to a considerable size in Guanacaste. At night the lights of shrimp fishermen can be seen as they cruise up and down the streams searching for this much-cherished animal. Shrimp command high prices.

Apart from the *Tilapia*, little is known about the potential of the fishes mentioned above and there may be others far more suitable. The culture of freshwater shrimp is still in the experimental stages, but research on the rearing of *Macrobrachium* is now going on in the Pacific and other parts of the world.

With some support and a few years of dedicated and patient study it is my contention that highly productive aquafarms could become operational in Guanacaste and other regions of Costa Rica. Such farms would provide an essential link in the reconstruction of this beautiful region.

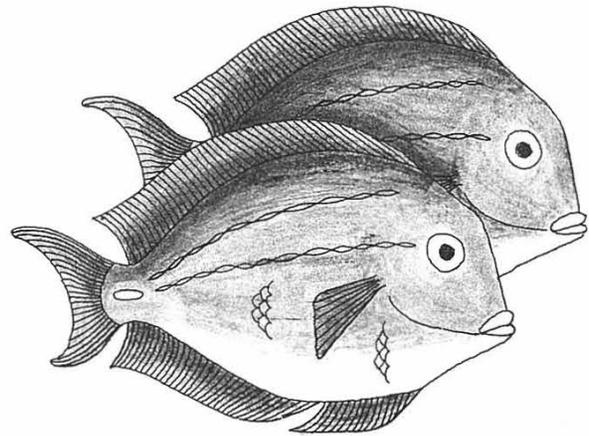
Polyculture Ponds as a Substrate for Intensive Gardens

It should be possible to devise crop rotation schemes to take advantage of the rich pond muck produced from the fish and crustacea waste products and from the remains of algae and zooplankton (microscopic aquatic animals). If the ponds were drained for irrigation pur-

poses after the fish were harvested, then a fertile weed and pest-free bed would be available for the intensive gardening of valuable market crops.

Polyculture Ponds for Irrigation and Fertilization

During the drier periods of the year the ponds could play a primary role in water management on Guanacaste farms. The water would be much needed for livestock and irrigation. Water could be transported by pipes, aqueducts and ditches or pumped by windmills to the pastures, gardens and tree crops. The strong winds of the area during the dry season favor the use of wind-driven systems in the flatter terrain, while along the hillsides the more traditional ditches might prove entirely adequate for the transport of water.



There is good reason to suspect that the pond waters will also add to the fertility and productivity of the soil. The water filled with dense blooms of algae, microscopic animals and their nitrogenous waste products could well act as a liquid fertilizer, especially if the polyculture ponds have been previously enriched by cattle, hog and fowl manures. A few years ago I carried out a small experiment growing parsley and lettuce under the dry conditions found in my laboratory office during the winter. Plants irrigated with water from aquaria with a high density of fishes grew faster and were larger than those grown with tap water. Bill McLarney's field trials with lettuce on Cape Cod are yielding similar results. In arid areas the fertilizing effect of the water from polyculture ponds might prove important for some crops.

Reforestation

The borders and hilltops of the ecologically-derived farms should be allowed to return to natural forests in order to stabilize internal climates and to make the farms more complete ecologically and economically. The advantages of reforestation are many. Forests break the strong winds and provide a diverse variety of plants and animals including insectivorous birds and predatory insects, which in their turn could help to keep pest popu-

lations in check. No doubt the wild forests will also house nuisance animals capable of damaging crops; however, their control might best be effected by separating the woods from the fruit and nut groves and vegetable crops by pastures and meadows. The forests might not only add to the biological stability of the farms, but they could within a few decades increasingly provide a new source of income from the selective cutting and sustained management of timber. The farms would have a continuous source of building materials and a cash crop if the woods are managed wisely. Wood as fuel is still important in Costa Rica and with petroleum shortages already a reality there, woodlots could stabilize somewhat self-sufficient farming regions by providing wood for cooking and also for the manufacture of wood alcohol for machinery that could not be run from wind-driven generators.

The forests then can be seen as another vital link in the restoration of regions like Guanacaste. They will act as windbreaks, captors of moisture, holders of the precious soils, sources of biological diversity, havens for the heat for grazing animals, sources of lumber and wood fuel, and as a home for increasingly beleaguered wildlife. Even in the tropics, reforestation, because of the time involved for a woods to become established, requires a prodigious commitment to the future, perhaps even beyond the lifetimes of many of us. But there is no meaningful alternative to this commitment and hopefully it will flourish in Costa Rica.

Stewardship and Land Restoration in the Humid Tropics

The Atlantic slope of Costa Rica, including the Rio Sarapiquí region described previously, is threatened. The agriculture and forestry of the area are primarily exploitive: forests are felled en masse for timber then the exposed areas are planted to grasses for the raising of cattle. The soils, when used as pastures, are exposed to the high temperatures and to an inordinate amount of leaching from the torrential rains, so that within a few brief years the land loses its productivity and sustains only the coarsest grasses and herbacious plants.

The exploiters for their part usually profit well from the stored fertility of the land accumulated over decades or centuries. Having withdrawn the biological capital of the region, they then move on to remaining forested regions to repeat their rapine acts upon the landscapes of the humid tropics. This is the predominant mode of land use and it represents a form of agricultural imperialism which threatens the poorer peoples who settled in these potentially bountiful regions.

But there is an alternative to the misuse of land in the humid tropics. The knowledge and techniques exist that would permit wise modes of farming a diverse array of foods while maintaining soil fertility, perhaps indefinitely.

ly. The basis for an alternative tropical agriculture is swiddening, a method of land use which evolved independently many millenia ago throughout the world's tropics. Swiddening, actually a form of gardening, has supported a great variety of human societies until modern times and the principles employed may well hold the key to the future in the wet tropics of the Americas. Modern analogs of swiddening need to be created which also incorporate some of the best findings of ecology and the forestry and agricultural sciences and new tools must be designed for unique conditions created by these analogs. If this came about, there would be a rebirth of societies highly adapted to the wet tropics. An agriculture with its origins in swiddening may perhaps be the only path for the future. It would be deeply rooted in the finest methods of the past but it would not be limited by them. We know that brilliant civilizations once flourished in the lowlands near the equator. The Mayans, for example, wrought elaborate and beautiful monoliths, sculptures and buildings and their triumph was no accident or quirk of nature. For centuries they must have farmed well, carefully heeding the processes of nature herself, and by so doing they had the health and desire to bequeath their mark upon the world.

I have wondered if the decline of the Mayan civilizations was at least in part a result of their societies becoming rigidly stratified. In the end their rulers and priests were no longer close to the soil, so they lost their direct involvement with the forces which sustained them. Decisions were made which were in conflict with nature because they no longer felt her.

SWIDDENING: A PRACTICAL AND CONCEPTUAL GUIDE TO LAND USE

Swiddening is often erroneously considered one of the crudest forms of farming, practiced by the most primitive of peoples. It is equated with cutting and burning of trees for the preparation of the land for crops. This is true but swiddening goes much deeper for in recent times it has been learned that it is one of the most subtle methods of raising foods. Its practitioners have a profound appreciation of the nature of the forest ecosystem to the point where their gardens have a structural similarity to the rainforests which surround them. Swiddening is a form of gardening which uses three-dimensional space and variations in light almost as efficiently as the oriental fish polyculturist does in his ponds.

Traditional swiddening is characterized by the rudimentary nature of the energy involved. Fire, human muscles and the simplest of tools are all that are needed. Despite this, it apparently makes light demands on individual farmers while providing almost all their dietary requirements. Further, swiddening alters the ecosystem less than any other mode of farming of comparable production.

My description of swiddening is primarily based upon the observations and researches of Roy Rappaport who

observed its practice in the tropical rainforests of New Guinea by Tsembaga peoples (3).

At least 90% of the lands under a properly managed swiddening regime are allowed to lie fallow and return to secondary growth forest. Despite the fact that a tremendous amount of land is in a "wild" state, the entire Tsembaga territory supports a population density of 97 per square mile and their best lands support a density of approximately 200 persons per square mile; and they do this without degrading or despoiling the environment. (Costa Rica presently has between 95-100 persons per square mile, including San José.)

It is possible to imagine small cultivated plots intensely cropped and dotted throughout the forest. The forest itself contributes by providing its share of wild animals and hundreds of forest plants which are used in the manufacture of tools, house construction, dyes, clothing, drugs and medicines.

Since each garden is tended for at the most a few years, old gardens are frequently abandoned and each family is therefore almost always involved in the preparation and planting of new ones.

The first step in swiddening is the clearing of the underbrush and this task is carried out with machetes. This is hard work involving both sexes and takes up a considerable amount of energy. Several weeks are allowed to pass then the trees are cleared. They are felled then stripped of branches which are piled up on top of the slashed undergrowth. Trees with large trunks are left standing, while the remainder are dragged to the edge of the garden.

The felled trees are split and lashed together with vines to make a pig fence around the garden. The fences keep the domestic and wild pigs out of the garden when it is in use, and after it is abandoned the domestic pigs are often penned on the inside to root out the remaining crops.

After the fences are built the litter is burned as the weather becomes suitable. The burning is a crucial step as it eliminates the underbrush at the same time as it liberates minerals from the forest vegetation for the crops. Some of the lighter unburned logs are used for terracing to hold the soil while other logs mark the various plots.

The next stage in swiddening is the planting of the gardens. The Tsembaga people know and use some 264 varieties of edible plants from some 36 plant species. The starchy foods they commonly plant are several varieties each of taro (*Colocasia esculenta*), sweet potato (*Ipomoea batatas*), yams (*Dioscorea*), cassava (*Manihot dulcis*) and bananas (*Musa sapientum*). Several of these are fed to the pigs, and in fact each family has two gardens, one for their own consumption and another of comparable size for their pigs.

Other foods are beans (various), peas (various), maize (*Zea mays*), sugar cane (*Saccharum officinarum*) and a diversity of leafy greens. Hibiscus leaves (*Hibiscus*

maniot) are an especially important source of protein. Cucumbers, pumpkins, watercress and breadfruit are also cultured as minor crops and the flowers of the New Guinea asparagus (*Setaria palmaefolia*) and pitpit (*Saccharum edule*), a relative of sugarcane, are relished. The fruit of one of the screw pines (*Marita*) is used as a sauce on the greens.

Although seeds are used, cuttings are the main source of planting stock and the gathering and planting of the cuttings is a very critical step. Holes are punched in the untilled ground and the cuttings or seeds are placed in the holes and covered.

The growth of the garden must represent an unbelievable sight when really well done. Here the fine art of ecological design stands out clearly. Rappoport's description illustrates applied ecology at its best in the tropics.

"In the garden, as in the forest, species are not segregated by rows or sections but are intricately intermingled, so that as they mature the garden becomes stratified and the plants make maximum use of surface area and of variations in vertical dimensions. For example, taro and sweet potato tubers mature just below the surface; the cassava root lies deeper and the yams are the deepest of all. A mat of sweet potato leaves covers the soil at ground level. The taro leaves project above this mat; the hibiscus, sugarcane and pitpit stand higher still and the fronds of the banana spread out above the rest. This intermingling does more than make the best use of a fixed volume. It also discourages plant-specific insect pests, it allows advantage to be taken of slight variations in garden habitats, it is protective of the thin tropical soils and it achieves high photosynthetic efficiency."

Weeding in the garden becomes a continual and essential task. Successive weeding is even known by specific names and they are carried out in order to uproot herbacious competitors of the crops. A fascinating fact is that tree seedlings are carefully protected and allowed to grow unimpeded, as it is recognized that soils' fertility can only be quickly restored through regenerating trees. Little trees are known to them as "duk mi" which means "mother of gardens". The presence of seedlings prevents grasses from invading and subsequently driving the ecosystem backwards to its simplest, unstable and most infertile state. Young trees capture the nutrients and reach down into the earth so that there will be fertility for future gardens.

What the swidden gardener is doing with an amazing foresight is going beyond caring for the species which feed him. The species of the forest are also cultivated and cared for as he knows that the future of his society depends upon these acts.

With the creation of a new garden every year or two the old garden is visited less frequently and it passes through the various stages on its way to becoming a forest again.

There is another interesting aspect of swiddening worth mentioning here. Professor Rappoport found that swid-

dening was efficient, despite the fact that it drew upon no elements of modern technology or outside sources of energy such as electricity or fossil fuels. The ratio of yields to input in the gardens is high, varying from 16:1 to 20:1. In light of the non-exploitive techniques involved this represents an efficient and productive form of earth stewardship. We have much to learn from the "primitive" gardeners in the humid tropical forests.

MODERN ANALOGS OF SWIDDENING

Modern man will never return to swiddening in the traditional way. Most people have lost the religious and social rationale for living such autonomous lives and they are far too irresistibly drawn to many of the trappings of the industrial societies to want to return to living without some of the tools and machines developed by "advanced" societies.

In a swiddening society everyone was a farmer and I do not think that farming as a universal occupation is either possible or desirable. Traditional swiddening could not be superimposed onto a contemporary tropical country without changes that would integrate it into the larger economic community. The swiddening farmer had no means of storing or transporting excess produce so cash inflow was unknown to him. His only cash crop might have been pigs, but in the case of the Tsembaga, they were slaughtered for religious festivals rather than for profit.

Nevertheless, if we are to become successful stewards of the humid tropical lowlands, we will have to draw inspiration for our efforts from traditional swiddening. In fact it is absolutely essential that the best methods of the past be emulated in designing the farms of the future. A relatively self-sufficient, modern system of swiddening could be developed which would also produce an excess of transportable foods for sale on the open markets and in my opinion this goal of creating productive and valuable farms could be accomplished without depleting the fertility of the vulnerable lowland soils.

Having been optimistic about the future, I must also introduce a strong note of caution at this juncture. Animals should definitely play an elemental role in the shaping of modern analogs, but the raising of cattle and other grazing animals should be avoided like the plague in the wet lowlands.

I do not think it was an accident that swiddening peoples in the old world raised pigs and avoided husbanding cattle. Cattle survive on grasses and in rainy tropical regions the coarse grasses can arrest the recovery of ecosystems and thereby stop or seriously hinder the regeneration of the soils (14). In fact grasses that are grazed can push ecological succession backwards, increasingly impoverishing the land. The rearing of pigs and fishes need not do any such thing and wisely managed they can play an important role in maintaining and improving the soil.

Alexander Skutch believes that one of the major reasons that civilizations of a high order flourished in the

lowlands of the Americas for centuries before the European invasions was simply because the Mayans and others did not combine grazing with agriculture. I think there is genuine merit in Dr. Skutch's ideas. The raising of cattle in Costa Rica should be confined to the mountains and the drier western lands.

Swiddening, forestry and perennial food crops must provide the foundation of agriculture in the wet lowlands. It would be wise to superimpose upon these aquaculture and the rearing of pigs and fowl. These animals can be optimally raised in these regions and will add to the efficiency and profitability of the farms. Only very small pastures should be permitted so that draft animals and the family milk cow can have a place to graze.

A Biologically-Derived Farm for the Wet Tropics

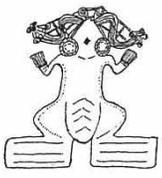
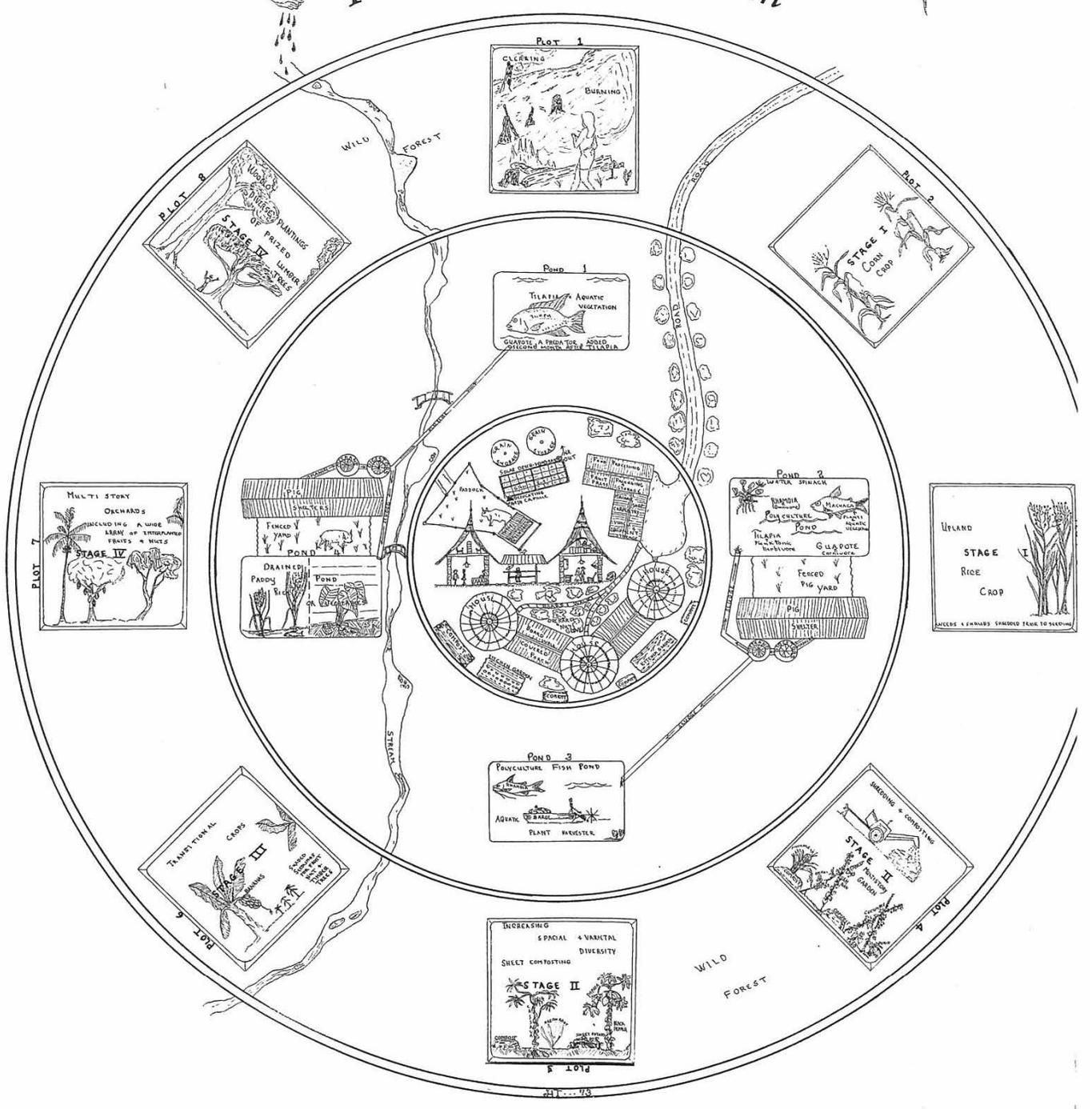
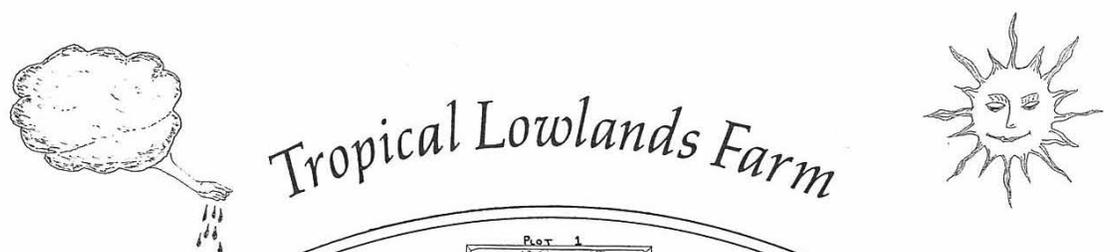
The farms of the future that I envisage would be unique, especially in the tropics of the Americas. They would be diverse and productive and would need a variety of machines to enable the farmer best to mirror the patterns of nature. At no time would the primary biological processes that characterize the ecosystems of each region be violated.

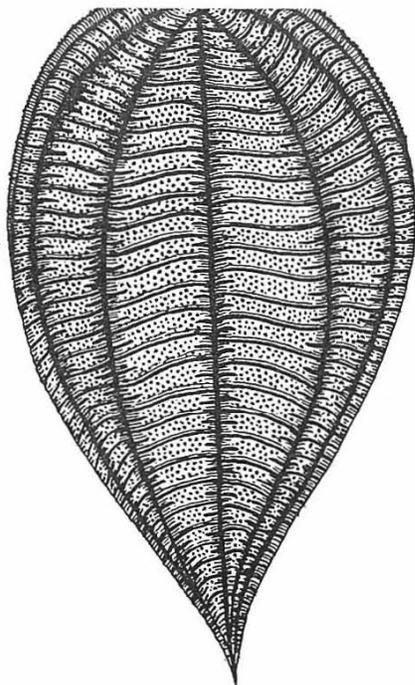
In order to combine ecological strategies with economic efficiency and productivity, each farm should perhaps be small, possibly limited to 50 acres or less. The reasons for the size limitation are straightforward: In a highly complex and productive agricultural system each element requires much more human attention and the orchestration of the farm as a whole necessitates a high degree of familiarity and understanding of each of the components. The size of the farm would best be limited to what the farmer can observe and supervise directly. It may be that this size limit would prove most viable economically, especially if there are cooperative schemes for processing and marketing of the foods on a regional basis. Smaller land units would also make possible a farming life for people with relatively little capital and land.

I want to describe a farm of the future with its roots in the past, which is only an idea and dream of what might be. My inspiration has been derived from many sources and from a number of different cultures. Perhaps not all of them can fit into Latin American cultures although most of them now exist there in one form or other. While some of the components are being tested on farms like the one at Granjas Tropicales, the various elements have yet to be woven together into a fully ecological farm that is reconstructive and profitable. The aquacultural components at this point are still at the exploratory stages.

Some of my suggestions might be off the mark, but hopefully they will stimulate new research and experimentation by many who intend to make the lowlands of Costa Rica their home.

Tropical Lowlands Farm





THE FARM

A model farm of the future should be carved out of the rainforest so that it may begin with the stored fertility of decades of biological activity. The land should not be entirely cleared, but have a series of small clearings of several acres each which would ring the farm. The small clearings, enclosed within the forest, will help ensure some ecological stability around each cultured plot and when the clearings are re-invaded, it will be with plants that are most likely to heal the degraded agricultural sites. These will be the seedlings of the forest itself.

Picture, if you will, a forested farm opened up over a period of years into a series of clearings around the perimeter of the farm. If you were to fly overhead you would see that each clearing is separated from the others by climax forest and since the clearing has taken place over a number of years, each opening would be different. Looking like wide spokes on a large wheel, each plot would be made up of different crops suited to the particular stage of maturity of the clearing. After a number of years the first or earliest opening would be hardly distinguishable from the surrounding forest being comprised of mature trees cultured from fruits, nuts, seeds, and high quality timber. The most recent clearings on the other hand might appear bare or charred from recent cutting and burning.

The houses and outbuildings might best be situated in the hub or center of the farm and outward from these polyculture fish ponds could be dug to create an inner ring which would appear like a sectioned moat from above. The pens and shelters for the pigs and

fowl would be between the ponds and the forest, close to the ponds. Within the interior of the farm could be the buildings for food processing, areas for composting and household orchards, and small garden plots.

The symmetry of the model farm has a purpose. It should enable it to develop sequentially and logically from a forested area to a farm that is characterized by its affinities with the forest.

PREPARATION AND MAINTENANCE OF THE FARMING AND FORESTRY PLOTS

As was mentioned, the size of each agricultural clearing should be limited. This would insure that invasions of coarse weeds and grasses would be somewhat restricted and the life of the plot, if properly managed, could be extended for perhaps many years. Paul Harcombe (14) has recently pointed out how small openings in mature forests are filled by climax species by means of vegetative reproduction, release of suppressed saplings, or by the germination of buried seeds. This is significant for the tropical farmer as it means he would have to contend with woody plants in the cultured plots which is easier than controlling grasses and herbs. Also, he would have on hand saplings of wild trees to provide shade and support for his crops.

The first step in clearing would be to cut away undergrowth. This would have to be done with machetes. Then the largest trees would be removed for sale as timber and small trees would be burned within the clearing. The intermediate and small trees would be burned within the clearing.

Burning, the next step, would not only help to release the nutrients and eliminate litter (which could also be accomplished by using a shrub chopper followed by mulching), but equally important the burning would destroy the roots and rhizomes of the original vegetation.

TRADITIONAL CROPS

Stage 1:

After clearing and burning the plots would be ready for planting of the stage 1 crops. Traditionally, these have been corn, which requires a lot of available fertility, and dry or upland rice. Plots in their first season might best be planted to these crops and excess production beyond the needs of the human community could be fed to pigs and poultry, or sold.

If the reinvasion of the plot was slow enough, it might be possible to plant the same crops a second time, especially if a mechanical chopper-shredder was used to shred the stalks and the woody plants and vines into a mulch. The mulch might slow down the rate of subsequent reinvasion and somewhat arrest the loss of nutrients from the soil. The type of chopper-shredder I am referring to is the large, gasoline-powered, transportable machine commonly used for disposing of shrubs, branches and small trees in northern U. S. communities. Its role in tomorrow's tropical farming might well be an important one. They could be drawn by oxen or by tractors.

Stage 2: Chopping, Composting and Raising Diverse Food Crops

The strategy through the second stage of the cleared plot would be to restore some of its fertility while growing a wide variety of crops suitable for sale and for consumption by the farm community and animals.

Although the method needs testing and experimentation, it is likely that some fertility could be restored through the chopping and shredding of the plants that have invaded the plots into windrows several feet deep. The windrows, in rows throughout the plot, would be inoculated with some soil and pig manure and allowed to compost. The compost when matured could be spread throughout the plot as a fertilizer.

The stage 2 gardens would be planted between the compost windrows. They would be multistory and diverse, like traditional swiddening gardens. Beans, peas, a variety of vine crops such as pumpkins, squashes, as well as root crops should be tried. Other less well known indigenous food crops could also be planted at this stage. Many of these could be valuable and saleable foods, while others would be solely for consumption by the people and animals on the farm.

Although it has not been demonstrated in the lowlands of the Americas, composting could well build up the soil's fertility. If this is found to be the case, then stage 2 crops might also include plants that produce for several years such as papaya, pepper and other spices. Those crops requiring support could be fastened to saplings that sprout up naturally and are permitted to grow to a particular height then topped and debranched.

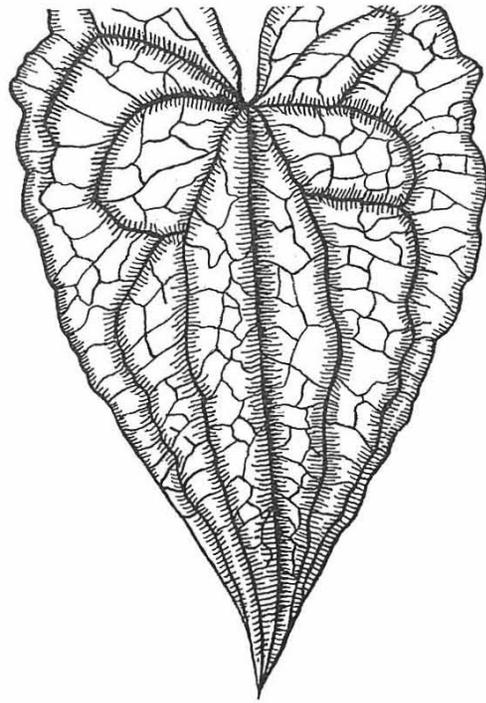
In order to slow the invasion of the site, cutting, shredding and sheet composting would need to be continued along the rows. Sheet composting is labor-saving but slightly less valuable compared with the traditional pile method, and consists of the shredded materials being allowed to decompose in shallow layers on the soil surface. The above techniques might allow the tropical farmer to continue the stage 2 process for five or six years, especially if, through composting, he was able to return to the soil the fertility he was removing with his crops.

Stage 3: Transitional Crops

The next stage is a transitional one in which bananas and plaintains are grown in the aging plots. Some seedlings would be allowed to grow up as well as to act as supplementary shade for the next stage. Shredding and sheet composting of plant materials should continue through this stage although less frequently. The bananas and plaintains have a wide variety of uses. The fruit would be for human and animal consumption and the leaves might be suitable as a food source for some of the cultured fishes.

Stage 4: Multistory Tree Crops

Stage 4 represents the final step of the farm plot to a mature and productive agricultural system. In the shade of the bananas and wild trees, a suitable habitat would



exist for seedlings of a great variety of potentially valuable tree crops.

Some plots could be planted to trees prized for their rare wood. Within a decade or two, with relatively little management after the first year or so, a timber crop of high value could be produced and sold, perhaps directly to brokers who deal in the finest tropical woods. Applied research into the growing of lumber crops of this type would reap rich dividends for any lowland region.

At the end of stage 4, when the trees are cut, the plot would be ready to return to stage 1 and the cycle would be repeated. Different cycles of varying duration could be tested on every farm.

The second approach to the stage 4 plots would be to plant a variety of fruit, seed and nut tree crops. These tropical orchards would begin to produce an income within a decade or less depending upon the crop. Each plot should have a number of different kinds of crops, varying in height and shade and root depth requirements. Many of the fruits could be processed locally or on the farm. Tropical juices, pressed and pasteurized, or sterilized would be very much in demand and could provide the basis for local agricultural industries. Many of the nuts and seeds command respectable prices for the farmer.

I do not have the experience or knowledge of tropical orchards to recommend the most suitable trees for the lowlands. Already cacao and rubber are important tree crops, but their prices are tied to fickle world markets. With many of the improved methods of processing foods, it would seem that the time is ripe to comb the world for suitable tree crops for the lowlands of the Americas. As

a biologist I have a bias towards indigenous or native crops, but there may be many trees that would add considerably to Costa Rican tree farming. An effort should be made in the immediate future to involve scientists, agriculturalists, farmers and the Costa Rican government in the establishment of a tree introduction center in the lowlands. The center would evaluate the suitability of promising trees for the culture of foods in Costa Rica. A few farmers are now experimenting on their own but a coordinated effort to test nursery stock and to make it available is urgently needed. Perennials, especially trees, are the plants best adapted to rainy tropical environments.

Stages 1-4 represent a man-made successional farm uniquely suited to the rain forests of Central America. At each stage the diversity and productivity climbs, and if properly conceived, the value of the crop should go up at each stage. Each swidden area has evolved into a highly cultivated, multistory orchard or grove of valued trees and the farm itself is protected by wild forest.

ANIMALS AND ENERGY: A BIOLOGICAL APPROACH

At the heart of the farm I am describing would be a complex for the culturing and raising of animals. The various components of the animal husbandry systems would be linked together. Each element would contribute significantly to the functioning of the whole, resulting in an advanced and profitable farm ecosystem. Pigs would be raised adjacent to the ponds and would be fed farm crops and aquatic plants. The pig wastes would provide the raw material for a methane generating plant capable of producing electricity and heat, the latter to be used for drying some of the crops. The methane plant wastes in turn would be cycled into the ponds to act as the major pond fertilizer. The enriched ponds would be productive of algae which represent the primary food input for polyculture fish farming. The raising of animals, especially pigs and fishes, could be achieved efficiently and optimally on a lowland farm. All the feeds would be grown on the farm, especially in the agricultural plots ringing the farm, and from the ponds themselves. Farms of this type could help meet the increasing demand for high quality pork and fish on a local and national basis. In fact the hot, tropical lowlands represent the very best environment for these activities.

PIGS AND FOWL

The potential for the raising of pigs and ducks in conjunction with the culturing of fishes is great and represents an extremely productive way of bringing together agricultural food chains in a mutually beneficial way. Recall the 4.4 hectare Chinese farm in Malaysia in which pig, fish and aquatic plants were raised together. Some 30,000 kg per year (approximately 66,000 lbs) of pig meat were produced with the primary feed being the aquatic water spinach (*Ipomoea repens*) which grew

luxuriantly in the fish ponds fertilized by the pig manure. Besides the pigs, some 3,000 kg (6,600 lbs) of fish were cultured in the small ponds. The fish in turn fed primarily off the algae which proliferated in the enriched ponds.

Ducks could complement a system like this, their wastes being added to the ponds and to the methane generating plant. However, to my knowledge, there is little in the way of markets for ducks in Central America at this time.

In the model Costa Rican farm the pig sties and duck pens should be situated close to the ponds. This would facilitate feeding of aquatic plants to the animals and permit the animal wastes to be treated near their eventual outfall back into the ponds. The sties and pens should have sloped concrete floors so that the manure could be flushed directly into a methane fuel plant, and all feeding of the animals would best be carried out in the pens. Attached to the animal shelters would be yards for the animals to exercise, root about and wallow. The yards would drain directly into the ponds below.

The numbers of pigs and ducks raised on the farm at any given time could vary, depending in part upon market conditions, availability of foods and the need for fuel or electricity from the animal wastes. If a methane plant is not desired, then the number of animals could be reduced. However, a farm scale fuel and electricity plant developed in South Africa by John Fry required the wastes from an average pig population averaging 1000 individuals (15). His was an intensively managed 25 acre farm.

Because of the diverse nature of the farm, a variety of suitable pig feeds would be available including aquatic plants, a number of root crops grown in the successional gardens, fish guts and heads, and if rapid gain was important, some of the farm-grown corn and rice could be used. The catholic tastes of the pig make it an ideally-suited animal for this type of tropical farm.

METHANE AND THE PRODUCTION OF ENERGY

One hundred pigs produce about 400 lbs. wet weight of manure daily and this material could be dumped directly into the ponds as a fertilizer, or used as manure on the crops. On the other hand it might best be cycled through a farm scale displacement digester in which the manure is broken down and methane gas is produced as one of the end products. Methane gas can be used directly as a fuel for machinery on the farm, or it can be used to power a diesel engine which has been converted for methane use. John Fry used his 13 hp converted diesel for generating electricity. A water pump was also driven directly from the engine. The system produced some 8,000 cubic feet of gas daily. At today's U. S. prices this is equivalent to approximately \$1,400 a year worth of fuel and the value of the effluent from the system could represent at least a comparable amount in

increased productivity in the fish ponds ringing the farm if they were properly managed. A detailed description of the system, including design information, has been given by Richard Merrill and John Fry in New Alchemy Institute Newsletter No. 3 (15). A methane system can be made to function reliably, as the Fry engine and digester combination ran continually with occasional stoppages for 6 years.

In tropical regions without a steady and reliable source of winds, the development of methane plants on a farm scale could help solve indigenous energy needs. The pig-methane-effluent-fish pond cycle takes advantage year round of the potential productivity of the tropics, with the effluent from the digesters becoming a critical factor in fish farming.

POLY CULTURE FISH PONDS

Much of the earlier discussion of pond culture on the hypothetical arid land farm in Guanacaste province applies equally along the humid and rainy Caribbean slope. Even the fish species cultured could be identical or closely related. The major difference between the small farm I am now describing and the Guanacaste model is that the effluent from the methane power plant would create more fertile and productive ponds in the humid lowlands. The ponds possibly could receive close to 1,000 gallons weekly of effluent originating from the pigs. If this energy could be trapped and used as efficiently as the Chinese in Malaysia manage in their ponds, then a major increase in high quality protein production could be achieved in the tropics of the Americas.

The fertilized ponds would be capable of producing prodigious amounts of algae and aquatic plants similar to the water spinach. The latter could be cultured in separate ponds or in combination with fishes, and would represent a substantial portion of the diet of the pigs. Fish culture would have to be designed around the food needs and ecological requirements of each species. A number of years of biological research will be needed to discover the most suitable fishes and to establish their stocking rates for polyculture in the Americas. Except for *Tilapia*, already introduced into Costa Rica, emphasis should be placed on native American species.

A possible roster of fishes to be tested are as follows:

| <i>Fish</i> | <i>Food and Habits</i> |
|--|--|
| <i>Tilapia</i> spp. | phytoplankton feeders |
| <i>Brycon</i> spp. (Machaca) | leaves, fruits and terrestrial and aquatic plants |
| <i>Rhamdia</i> spp. (pimelodid catfishes) | omnivorous, nocturnal feeders especially on benthic or bottom animals |
| <i>Cichlasoma</i> spp. (guapote) | predator introduced to prevent overpopulation, especially of <i>Tilapia</i> |
| <i>Joturus picbardi</i> sp. (bobó) | habits not known, but highly prized fish, noted for the quality of its flesh |

This is a hypothetical list and except for the *Tilapia* none of them to our knowledge have been cultured as a source of food, although all of them are sought by fishermen as food fish. The goal of New Alchemy fresh-water fish studies in Central America is to create analogs of oriental polyculture systems based upon fishes from the rich and diverse fauna native to the American tropics.

There still may remain the hurdle of marketing of fishes from the polyculture farms. Apart from local markets there is the distinct possibility that some of the species might be suitable for live transport to distant fish markets, while others could be sold freshly processed. In areas without inexpensive refrigeration, it would be necessary to process fishes locally for shelf storage. Some means for drying, smoking and "pickling" of fishes could be devised on a farm or local scale. Recently I had the pleasant experience of eating fish that were cooked and then preserved in olive oil, wine vinegar and garlic. The texture and taste was outstanding. A tropical equivalent might be to cook the fish briefly and then store them in a ceviche "sauce" which includes culantro, also known as Chinese parsley or coriander. Raw fish in this "sauce" is excellent and much appreciated in Costa Rica and other parts of Central America. Unsaleable fish could be used as feed for the pigs.

PADDY RICE CULTURE

The ponds, drained after the fish are cropped, would be ideal for growing paddy rice. The rich bottom muck would help ensure a bountiful harvest and a rotational scheme could be worked out to take advantage of ponds which occasionally lie fallow. Rice farming would diversify the farm's subsistence base and, if carried out on any scale, it could provide an additional income source.

Tragically, modern rice culture using the high yield strains of rice usually requires a variety of biocides including insecticides to nurse the crop through to its final stages. These poisons would be extremely harmful to the pond ecosystem, so if rice could not be grown organically in the region, then it should not be introduced as a crop on the model farm.

THE TECHNOLOGICAL BASES FOR MODERN TROPICAL FARMS

Space limitations prevent a detailed discussion of the kinds of technology that would be most helpful on the kinds of farms described in this article. Ecologically-derived farms would have unique requirements, which could not be completely met by established agricultural equipment manufacturers. In the long run, this vacuum might turn out to be a boon to tropical societies, as it might induce indigenous inventions or stimulate efforts where possible to substitute biological solutions for the strictly technological ones of orthodox agriculture. For example, there are two basic ways to control serious damage to crops from insect pests. One approach is to spray a monocrop with a powerful insecticide, whereas

the alternative is to use ecological strategies against pests which include limiting plot size and proximity and interplanting several crops in the same plot. The latter strategy represents a predominance of biological thinking, which, over the long term, could well prove most suitable against the vicissitudes of hot tropical environments.

Even on an ecologically-inspired farm a variety of machines would be needed as toil-saving devices and for increasing the efficiency of the farm and for processing of the foods for market. Oxen and horses should remain as beasts of burden on the farms of the future, as they require little in the way of capital and perform some tasks more efficiently than tractors or other vehicles, especially during the rainy season. They also do not require increasingly expensive gasoline and oil.

INDIGENOUS TECHNOLOGIES

Local economies and individual tropical farmers could be aided and strengthened by indigenous manufacturing of a variety of equipment and tools. Savonius rotors for pumping water, windmills for pumping or generating electricity (see "Energy" articles in this issue), simple pumps, many of the methane plant components, buildings and a variety of other useful devices could be produced on the farm or in local blacksmith shops. Some food processing equipment could also be built on the spot such as solar driers, fruit presses, solar and wind-powered ice making or freezer units.

As local engineer-crafters begin to develop proficiency, a tendency could evolve to turn to indigenous materials. One example comes immediately to mind, namely fabricating the piping for the water and aquaculture systems from large varieties of bamboo. As ecological farming practices are worked out, there will be a need for new kinds of planters, cultivators and harvesters. If these could be built locally, the diversity and economy of the regions affected would also be strengthened. The stability and social richness would be far greater than in farming areas based on single cash-crop farms or plantations.

IMPORTED TECHNOLOGIES

Some imported technology will be required to make the farms productive, efficient and a pleasure to work. Power saws and chopper-shredders will be needed for clearing and composting; and tractors might help with the turning of the compost, the digging of ponds and the moving of materials. Pasteurizing or sterilizing equipment and some power tools and vehicles for transporting food to markets will need to be brought in from outside.

The success of these farms and the communities associated with them will depend, to a large degree, on there being a healthy balance between the local manufacture of machinery, equipment and structures and the expensive imported aids for farming and living in the tropics. Farms like those I have described will need minimal outside equipment and machinery, but that

which is required will play an important role. Unfortunately, we still know very little about the most appropriate technologies for biologically-inspired tropical farms.

CAN IT ALL HAPPEN?

As I reflect upon the future, especially as it pertains to the tropics of Latin America, I am overwhelmed by how much has to be accomplished to reverse the course of land exploitation before the task becomes too difficult and whole regions have to be abandoned. Alternative farms will have to exist by the turn of the century, and they will have to appeal widely to tropical farmers—farms, like beacons upon a wasted sea.

But I am not optimistic about the future. The magnitude of the present dilemma is not clearly recognized, nor is there much chance of finding support to create model farms that represent, in microcosm, the most valuable of nature's processes. Frightening too is the tendency for agencies, organizations and governments to tackle problems on a piecemeal basis, and on too large a scale for individual farmers to relate to. I have observed that people react to new ideas or things very differently, and I suspect the reaction depends on whether the new idea or thing can be actualized by them within their present resources. Small farmers at agricultural fairs are no doubt impressed with the sight of computer consoles that can operate myriads of machines on a mechanized farm, but their reaction is quite different to people who see the small backyard fish farms at our Cape Cod center. These inexpensive little aquafarms are as strange as the consoles, but the immediate reaction is not one of awe, but is more likely to be "I'd like to try that". Anyone with a 25'x25' plot of land can have a small fish farm, but the remote and esoteric console and its array of machines exist in the realm of the "expert" and the large corporate farm. The viewer sees it as an occupant of a world other than his own.

Another variable that dampens my optimism is the tremendous amount of energy, scientific study and plain hard work that will be needed to construct viable alternatives. Our experience at the New Alchemy-East center has shown us how little is known and how much work is required. Not to be overlooked is the vital question of communicating knowledge and perspectives outward so the best approaches and strategies can become widely emulated. People everywhere must become experimenters with the world around them. To give them the necessary confidence is one of the most important but little discussed or understood tasks ahead.

A beginning has to be made, and soon, as the spectre of hardships before us is too great. Armed with what is already known, functional demonstration farms like the ones described should be researched and developed. Financial support will have to be sought as good experimentation will have to include the luxury of testing hunches and ideas that may well fail as well as those that

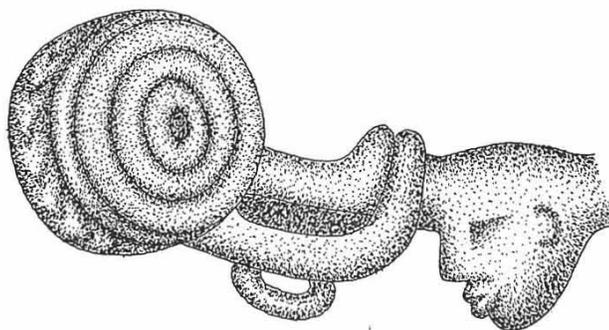
succeed. The search for modern tropical farming methods will not be a direct and straightforward path.

Local or regional governments could play an elemental role in the restoration, either by establishing models themselves or by underwriting some experimentation by farmers. Perhaps they could do both. Another valuable contribution would be the establishment of regional plant introduction groves, nurseries, hatcheries for fish, and pig breeding stations so that the best quality stock would be available inexpensively to farmers adopting ecological methods. Small international research organizations like New Alchemy should play a role too because of their ties with practices in other parts of the world. In specific terms we would like to continue and to expand the studies of Bill McLarney in searching for native fish species suitable for culturing. If the wherewithal can be found, we would also like to collaborate with local people in the establishment of a reconstructive farm in Costa Rica.

Another key step to bring about constructive change might be to establish throughout Costa Rica an independent organization of ecological farmers with the purpose of sharing ideas, stock, research notes and the spreading of bio-social ideas into the larger agricultural community. Cooperative and educational ventures should be emphasized. It should be run by full-time farmers desirous of making their country balanced and productive.

Costa Rica is a beautiful and potentially productive land. If a few people with vision and foresight were to embark upon some of the proposals that have been presented here, then one day a dynamic might be born that would fulfill its promise as a country blessed with restored and productive landscapes and a free and self-reliant people.

—John Todd



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A Preliminary Bibliography:

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This bibliography is a very tentative beginning. We intend to make it more complete. Please send us annotated references of books and papers that you have found significant. Technological references are important too, as we hope to publish a bibliography of "Technologies for the Tropics" in a future issue.

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