INSTITUTE OF CURRENT WORLD AFFAIRS

GSH-12: JARI

Apartado 8-3870
San Jose, Costa Rica
September, 1979

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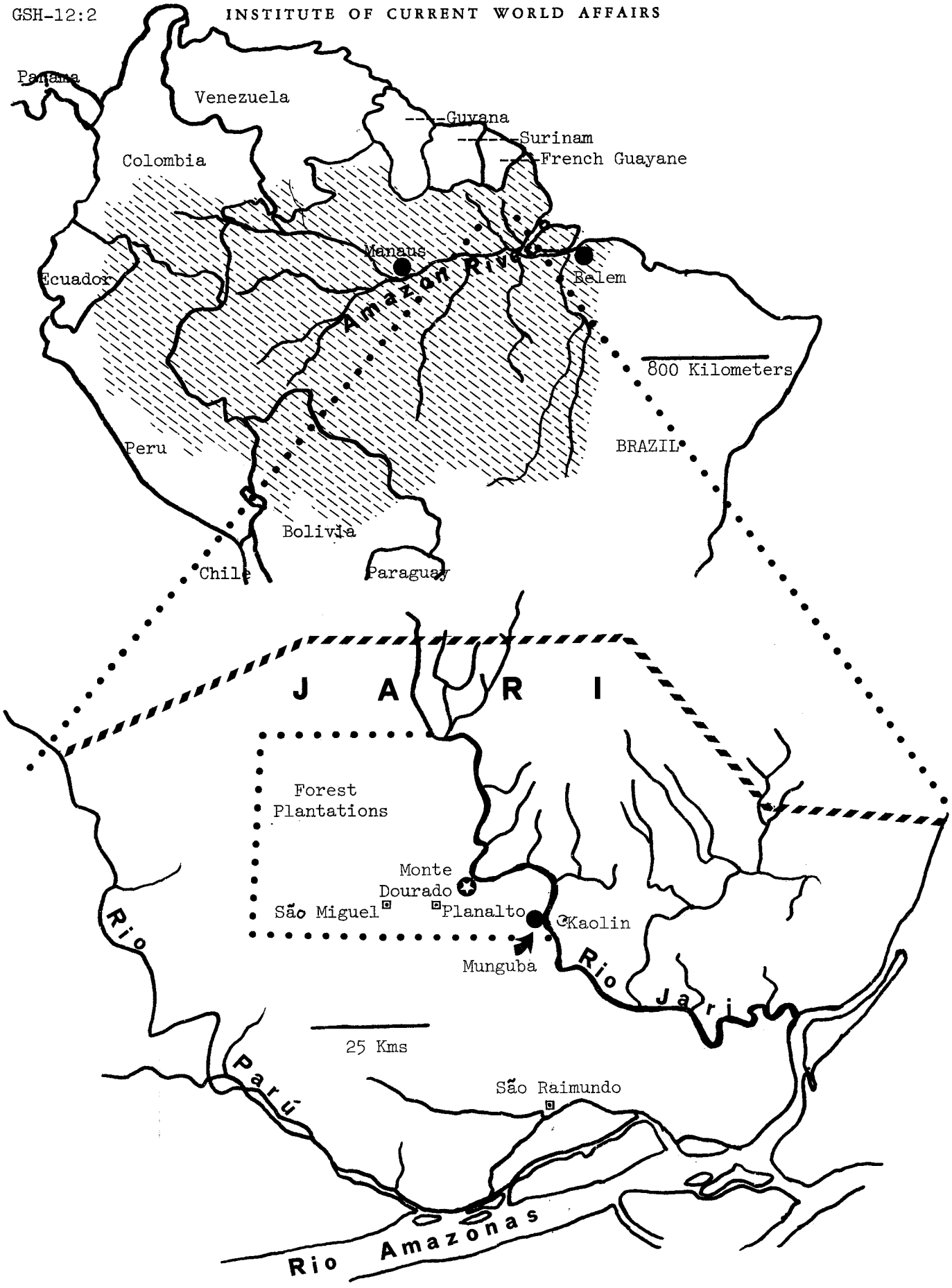
Dear Peter:

When trying to put JARI into context, I usually need only mention JARI was the Amazonian destination of the floating pulp mill built in Japan and towed across the Indian and Atlantic Oceans. Jari Florestal e Agropecuária Ltda. (Jari Forestry and Agricultural Enterprises) is the official name of Daniel K. Ludwig's project to produce wood fiber on a vast tree farm in the Amazon jungle. The immensity, boldness and audacity of Ludwig's JARI project has attracted worldwide attention. Pulp and Paper International magazine says JARI is the largest forest industry project ever undertaken by private enterprise.

Upon being named a Forest & Man Fellow, one of my top objectives was to visit JARI. At the Madison, Wisconsin, conference on Improved Utilization of Tropical Forests (GSH-2) in May, 1978, I had the opportunity to meet Dr. Charles B. Briscoe, manager of the forest management division of JARI. Brick --as he prefers to be called--gave preliminary approval for my visit. February didn't work out due to the change of venue of the tropical refugia symposium (GSH-9) from Brazil to Venezuela. The March-May period was inappropriate because of numerous visitors and consultants involved in the start-up of the pulp mill. Arrangements were finally completed for Lynne and me to visit JARI in late June.

Even though popular articles on JARI have appeared in newspapers and newsmagazines, it is appropriate to briefly review just what is JARI. In 1967, Ludwig purchased 1.6 million hectares (=16,000 $km^2$ =4 million acres = 6,175 $mi^2$, or about 20% larger than Connecticut) from a consortium of Brazilians for a reported $3 million. Ludwig's property (see map) occurs on both sides of the Jari River, the last major northern tributary to the Amazon River. Two-thirds of the property lies west of the Jari River, extending about 100 km to the Parú River in the Brazilian State of Pará. The remaining third east of the Jari River is in the federal territory of Amapá.

Primary rationale for purchasing such a vast area was to plant fast-growing trees for production of wood fiber. More than 25 years ago Daniel Ludwig is said to have predicted a world-wide shortage of paper products for the mid-1980's. His assistants are reputed to have scoured the tropics searching for a fast-growing tree with suitable wood qualities that could be used to make a wide array of paper and other reconstituted wood fiber products. Ludwig decided on the melina tree, a relative of teak (more on melina in a later section). Trial plantations of melina were established in Honduras, Costa Rica and tropical West Africa before Ludwig bought JARI.


Panama
Venezuela
Guyana
Surinam
French Guayane
Colombia
Manaus
Amazon River
Belem
Ecuador
800 Kilometers
Peru
BRAZIL
Bolivia
Chile
Paraguay
J A R I
Forest Plantations
Monte Dourado
São Miguel
Planalto
Kaolin
Munguba
Rio Jari
25 Kms
São Raimundo
Rio Amazonas

## Pre-visit Considerations and Expectations

JARI's tree-farming project has evoked considerable discussion and commentary by foresters, ecologists and conservationists. Ecologists question the capability of fragile and nutrient-poor tropical soils to support repetitive cropping of trees. Is Ludwig mining the productive capacity of tropical ecosystems? Conservationists decry the wholesale destruction of virgin forest with its hundreds of native species of plants and animals in order to establish pure plantations of a single species. All three groups raise the question of pest or disease outbreaks in the plantations. Conservationists worry that Ludwig's JARI project will stimulate an invasion of the Amazon Basin by multinational corporations to deforest vast tracts of Amazon forest. Foresters criticize the burning of huge volumes of native woods to prepare the land for tree-planting.

Brazilian law stipulates that developers and colonists in the Amazon must leave 50% of their property in undisturbed forest. Will JARI respect the law or skirt it by using its 50%, sell off the remaining 50% to a subsidiary that can then develop up to 50% of its new property?

For several years JARI has been cutting and burning native forest at an average rate of 5,000 ha/yr (12,500 acres). Some of my colleagues have shown me photographs of vast areas of bare soil etched with charred stumps and logs. JARI schedules forest cutting for the late rainy season and early dry season in order to get as complete a burn as possible in the late dry season. The annual JARI burn is so intense and immense it produces its own weather--severe thunderstorms some 10 km downwind from the conflagration. Dr. Eneas Salati, Brazilian meteorologist and director of the National Institute for Amazonian Research (INPA), has found that approximately 50% of the atmospheric water vapor in the Amazon region is a direct result of transpiration from Amazonian forests. Dr. Salati worries that the reduction in transpiration associated with large-scale deforestation will have profound effects on local rainfall.

JARI has made its share of mistakes; one of the most notorious was clearing the native forest with huge bulldozers that not only pushed down trees but also removed the thin topsoil. Without abundant nutrients in the topsoil, planted melina trees stagnated, failing to attain two meters of height in five years. Forest cutting is now done manually with axes and chainsaws. For the past seven years, the poorer sandy soils have been planted with Honduran pine trees, while melina plantations are restricted to the better soils.

Prior to my JARI visit, I was most concerned about the capability of tropical soils to remain productive under a repetitive cropping regime. Dr. Jean Dubois of the Interamerican Institute of Agricultural Sciences in Belém, Brazil, recently told me only 0.3% of Amazon Basin soils are sufficiently fertile to support sustainable agriculture. Most non-flooded soils in the Amazon Basin have low fertility, plus most of the nutrients present are tied-up in the forest vegetation. Tight nutrient cycling aided by the symbiotic association of mycorrizal fungi with tree roots greatly minimizes nutrient losses from decaying leaves and wood on the forest floor. Cutting and burning of forest breaks the tight nutrient cycle and heavy tropical rains cause substantial leaching of the released nutrients through the soil.

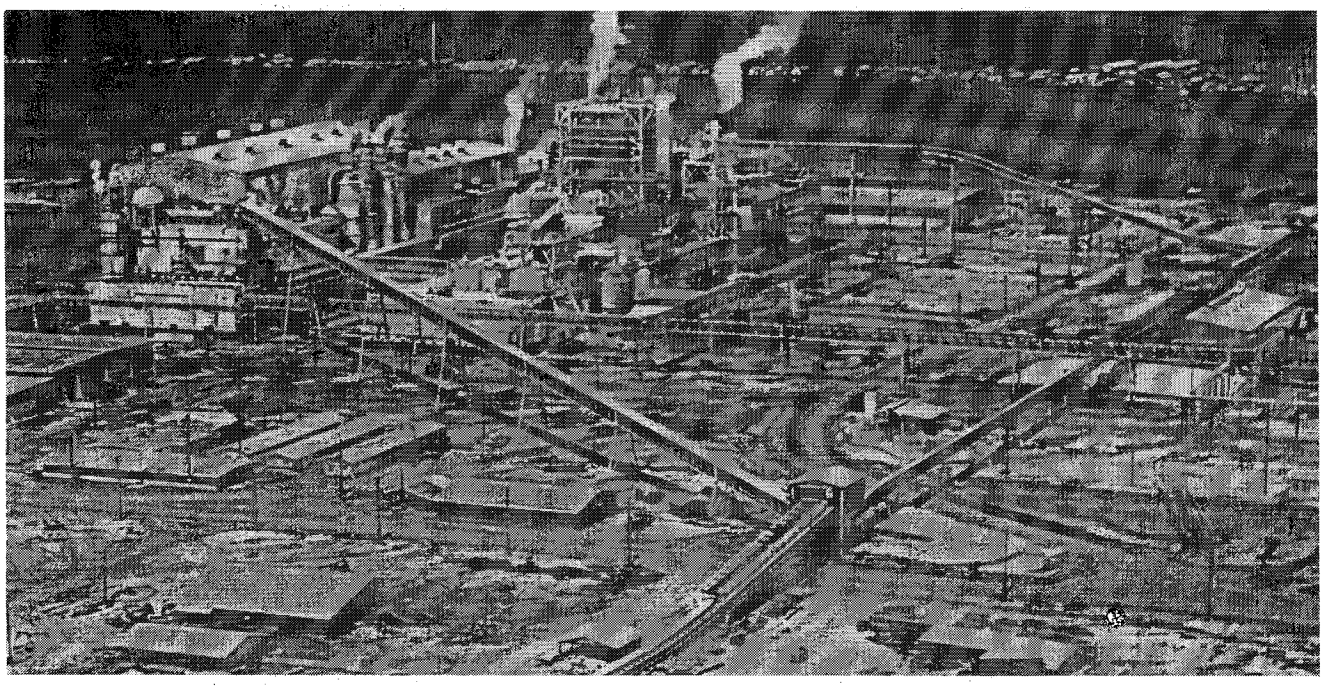
Rapid establishment of plant cover helps to stem the nutrient losses, but the first crop uses the nutrient-capital accumulated by the original forest. Ecologists debate whether or not repetitive harvesting of melina trees on a short rotation coupled with the export of substantial quantities of nutrients tied-up in melina wood will result in continued loss of soil fertility.

Substantive discussions with INPA scientists in Manaus strengthened my skepticism of JARI's probability of success with tropical tree-farming. INPA is one of the Brazilian foci of opposition to JARI's projects. One INPA scientist strongly criticizes JARI's conversion of varzea (floodplain) forest to rice fields. Due to an annual deposition of sediments from the Andes, varzea soils are very fertile and can support intensive and sustained agriculture. INPA scientists worry that JARI's successful rice operation will stimulate other agricultural projects on varzea soils. Large-scale destruction of varzea forests would have drastic effects on Amazon fish that depend entirely on fruits produced by trees growing in varzea forests. Some of the fruit-eating fish species are staple dietary components of people living along Amazonian rivers.

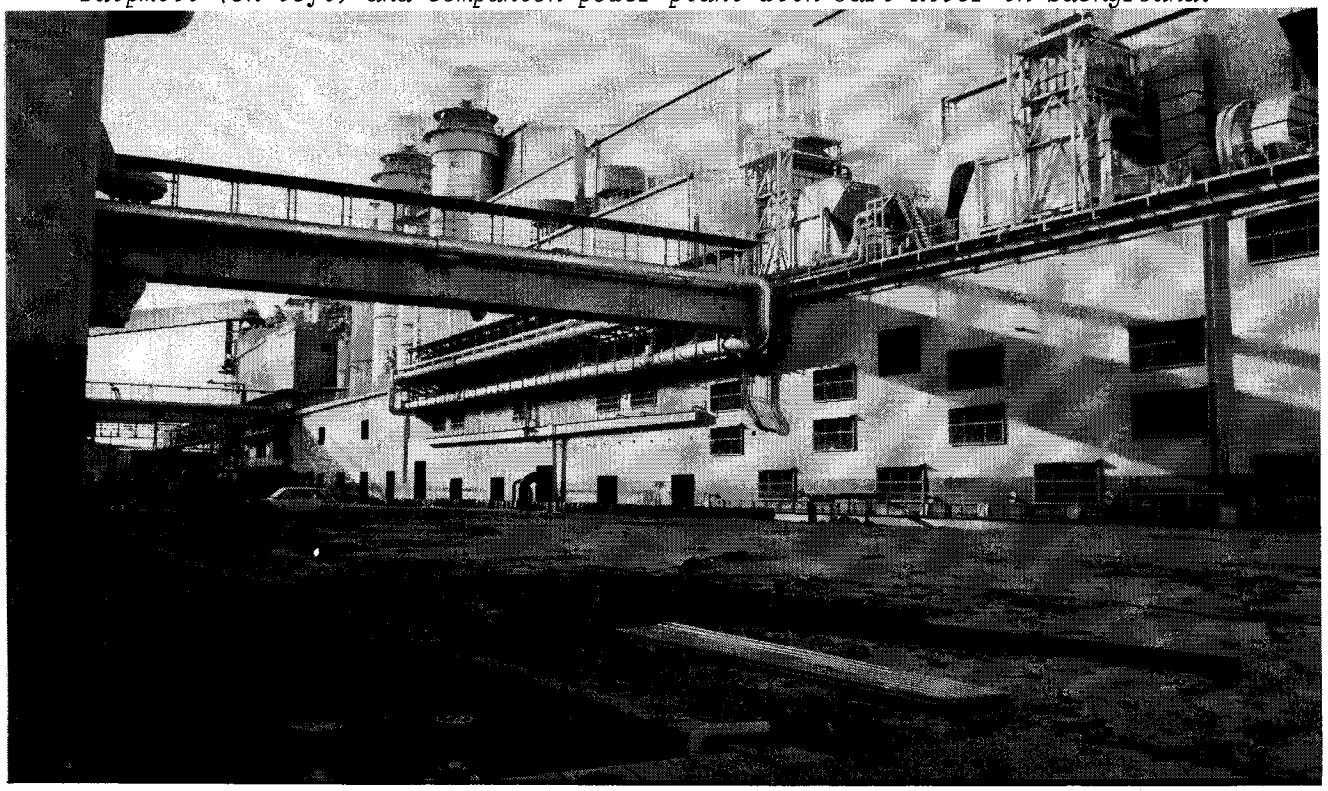
## JARI

Monte Dourado, the capital of "Jarilandia", is about 30 hours by boat from Belém, or an 80 minute flight by company plane. Our first glimpse of the small city from the plane revealed a well-organized community with row after row of identical houses. JARI must have employed an East Coast developer to build Monte Dourado, for there wasn't a single tree left from the original forest to provide shade or beauty. Some residents have planted melina trees near their houses, but an ornamental shade tree it is definitely not.

*Partial aerial view of Monte Dourado, JARI company headquarters and main residential community.*



*Pulpmill (on left) and companion power plant with Jari River in background.*



*Side view of the huge pulp mill, weighing 30,000 tons, that was towed from Japan to its berth along the Jari River.*

*Gary inspecting the piling arrangement under a corner of the power plant barge.*

Monte Dourado and two satellite villages have an estimated population of over 20,000 serviced by a 100-bed hospital with 12 physicians, several churches, international and Brazilian schools, two social clubs, a supermarket, two cafeterias, four guest houses, a post office, bank, and of course, numerous company offices and support facilities.

Brick met us at the Planalto airport and delivered us to the main guest house, a spacious 24-room motel-type building with a fine view of the Jari River.

Although Monte Dourado translates to "gold hill", it was named after the Jari engineer who chose the site, rather than for the discovery of gold. Nevertheless, the name has led to considerable confusion among visitors, particularly high Brazilian military officials, who insist on being shown the secretive gold-mining operation. They are incredulous such an investment is being made in trees.

Seventeen kilometers from Monte Dourado is the industrial center and port facility of Munguba along the Jari River. The power plant and pulp mill were designed in Finland, built in Japan on seaworthy barges, and towed 25,000 km in three months to berths at Munguba.

Perhaps the most telling example of the success of Ludwig's innovative engineering is after the two independent barges were seated on pilings, a large crane lifted a bridge in place to establish the first connection between them and the bolts aligned perfectly with the holes. JARI's engineers say that building the plants in Japan saved them at least two years of construction time. The pulpmill and companion power plant, chock-full of 4,000 tons of spare parts, entered Brazil under one import license and one set of customs documents. Anyone who has dealt with Latin American customs procedures will understand the significance of only one set of documents.

Also at Munguba are a large, integrated sawmill and a kaolin processing plant. The sawmill produces quality wood for export, with the residues chipped for boiler fuel in the power plant. The two steam boilers drive a 55 megawatt turbine generator that produces enough electricity for the entire Munguba industrial complex, plus Monte Dourado. Pulp and Paper International magazine says the JARI power plant is unique because the two boilers are designed to operate mainly with wood fuel; however, I have seen similar wood-fueled power plants supplying energy to integrated timber industries in other Latin American countries. The important point is that JARI is trying for energy self-sufficiency and integration. Non-commercial timber from about 4,000 ha/yr is required to fuel the boilers.

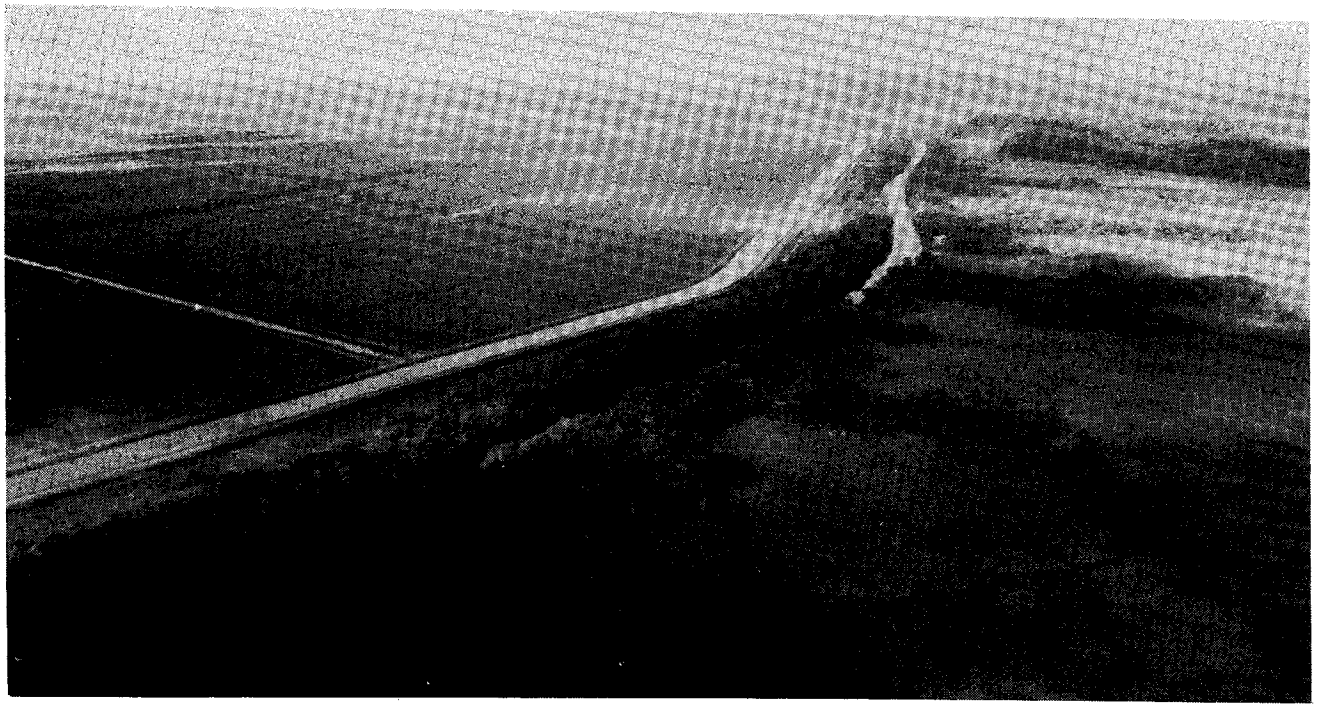
Kaolin is a fine clay used in making porcelain, paint, glossy paper and that well-known companion of veteran travelers--kaopectate. Kaolin is mined from large deposits east of the Jari River and pumped under the river to the processing plant at Munguba. It is said that Ludwig did not know of the kaolin deposits when he purchased the JARI property; JARI claims its supply of kaolin could last 400 years.

São Raimundo in the southern part of JARI is the center for cattle raising and rice farming operations. Both creole and water buffalo are used for beef production. During a quick visit to a water buffalo milking station on stilts, we were given a sample of water buffalo cheese made locally. Water buffalo milk contains 9% butterfat (twice that of regular cow's milk) and a greater quantity of milk solids than regular milk, thus it is ideal for cheese-making. We enjoyed watching JARI cowboys riding tipsy dugout canoes to herd the water buffalo across a river.

The 5,000 ha of rice fields produce two crops per year, with reported yields of 10-15 tons/ha/yr. The fields are double-diked to allow year-round control of water for the high-yielding paddy rice. A rice mill has been built at São Raimundo and JARI plans a four-fold increase in riceland within four years. From our overflight of the rice operations I saw no evidence of conversion of varzea forest to rice fields. It appeared to me most, if not all, of the rice fields were converted from the very extensive herbaceous swamps in the area.

Tree plantations already cover 100,000 ha (247,000 acres) of the region west and northwest of Munguba. Seventy-five km (45 mi) of railroad lines, 300 km (180 mi) of primary roads and 200 km of secondary roads service a 4,000 km (2,400 mi) network of plantation and forest roads. Pulp logs are hauled by truck to depots for railway transport to the pulpmill complex at Munguba.

*JARI cowboy herding water buffalo across a small branch of the Amazon River.*



*Extensive fields in upper left produce two crops per year of high yielding paddy rice. The double-diked canal system allows complete control of flooding and drainage. The herbaceous swamp in the lower right, rather than varzea forest, is converted to rice fields.*

The plantations are organized into 20,000 ha production blocks, with a professional forester responsible for each unit. Each block forester has a permanent labor force of six technical assistants and approximately 45 workers. Temporary labor requirements, such as forest clearing, plantation establishment, and weeding, are met with a large labor force of contract workers. Even though the need for mobile, contract labor will always be substantial, JARI is striving for permanence and stability of its labor force. To this end, JARI is building a complete village in each administrative plantation block. Each village, called a "silva villa", is designed for 750 families, complete with schools, a health clinic, stores and churches. Two silva villas, Planalto and São Miguel have already been completed. If a festival put on by the local school children of Planalto is an indicator, it appeared to us the silva villa concept is very successful in creating a viable and attractive community. The second silva villa at São Miguel is also the locale for the tree nursery, a productive vegetable farm and a large poultry operation.

## Melina: The Billion Dollar Tree

Daniel Ludwig's foresters are confident their melina trees can produce the 12,000 tons of wood digested daily by the pulp mill. The fast-growing melina trees are harvested after only six to seven years of growth. Is melina truly a wonder tree that not only is the keystone of Ludwig's $700 million investment in the Amazon but also a tree which might revolutionize tropical forestry?

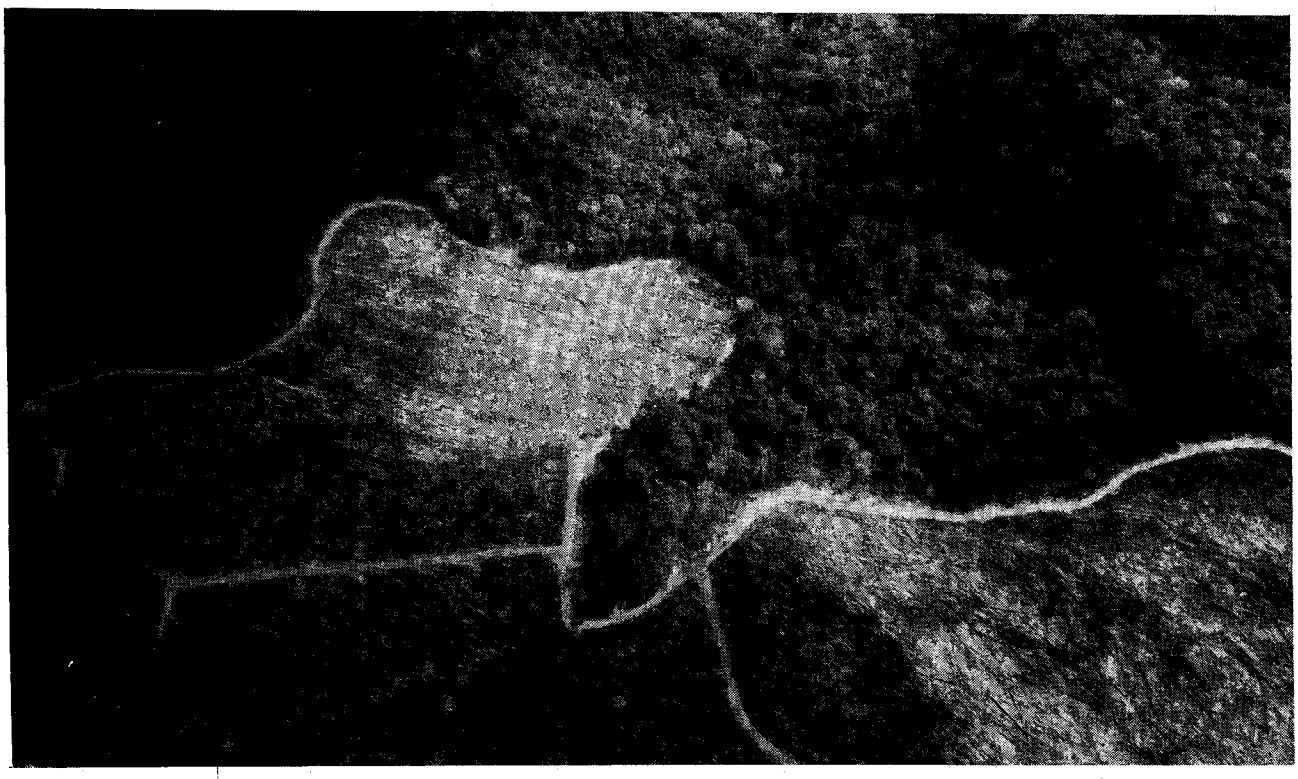
Known scientifically as *Gmelina arborea* in the verbena plant family (Verbenaceae), melina occurs naturally in a broad spectrum of subtropical forests of the Indian subcontinent and Indochina, with the exception of the Malay Peninsula. It is frequent in the moist forests of Burma, but much less abundant in drier forests. Ecologically, melina is a shade-intolerant, pioneer tree well-adapted to colonize disturbed areas. Tropical pioneer tree species are well-known for exceptionally fast growth; a seven year old melina plantation on a good site can produce 200 $m^3$/ha (=2,862 $ft^3$/acre) of pulpwood. Melina wood can be sawn for a variety of uses requiring medium light weight and dimensionally stable wood. It can also be peeled or sliced for plywood or veneer. JARI is leaving some of the best melina stands for saw timber to be harvested after 11 years.

I was surprised at the generally poor form of JARI's melina trees. Although the pronounced taper of the rather crooked boles is not critical for pulpwood, it certainly doesn't produce very suitable saw logs. When driving on JARI roads, we quickly learned to give wide berth to the tractor-trailor trucks carrying full-length melina boles because the crooked stems often protrude far outside the width of the truck. Tom Bush, a retired industrial forester serving as a consultant to JARI, remarked over dinner that because of its poor form, American foresters would have walked right by melina without ever considering it for plantation forestry. During one of our many drives through the plantation we saw some exceptionally straight and well-formed melina trees singled out for use in a genetic tree improvement program. It appears that JARI foresters are making substantial progress improving the form of their melina trees.

JARI Tree Farms

Of the 100,000 hectares (247,000 acres) of tree plantations already established, approximately two-thirds is in melina and the remainder in Honduran pine (*Pinus caribaea* variety *hondurensis*). Despite Ludwig's predilection for melina and the poor response of the early melina plantations on sandy soils mechanically cleared of forest, JARI foresters are reputed to have had to surrepticiously place trial plantings of pine away from Ludwig's eyes. Once the pine outgrew the stunted melina, Ludwig acquiesced to large-scale planting of pine. JARI foresters are pleased with the two-species approach, for Honduran pine does very well on the sandy soils that are not good sites for melina, whereas melina is doing very well on the clay and sandy-clay loam soils. JARI managers aren't unhappy either at the prospect of producing pine pulp, whose long fibers are in demand, and offer the possibility for producing high quality paper.

Most pine plantations are on the sandy soils in the southern half of the forestry project area--the Munguba, Planalto, São Miguel region. Melina plantations predominate in the northern area paralleling the Jari River on the more fertile red and red-yellow soils. Tree rotation periods for melina are seven years for pulp and 11 years for solid wood versus 11 years for pine pulp and 16 for solid pine wood. 1970 was the first year of extensive melina planting, while commercial pine plantations were not started until 1973. Melina harvesting started in January 1979, but pine pulpwood won't be available until 1984.



*Recently harvested melina plantation on the sandy soils of the Planalto to be replanted with pine. Undisturbed natural forest left by JARI on the steep slopes off the flat Planalto.*

*Trial plantings of several Eucalyptus species (right center) in a sea of two-year-old pine plantation.*

Upon arrival at JARI we were provided with a large map that enabled us to know the planting year of any of the plantations. After our introductory tour Brick provided us with a company car to visit the plantations and native forests; without the detailed plantation map we might still be groping our way over the maze of roads. During our ten days in JARI we made innumerable visits to plantations of all ages of both species, melina harvesting operations, second rotation melina plantations, natural forest logging and clearing operations and numerous experimental plantations. The following section of observations and commentary are organized along the logical sequence of the plantation forestry practices employed at JARI.

Natural Forest Conversion

The evaluation of a plantation site by a team of forestry and soils experts includes an inventory of timber volume by species in the natural forest to be cleared for plantations. Approximately 30 species or species groups are presently used to supply lumber for JARI construction needs. A recently completed large sawmill will permit JARI to process all the commercial timber available from the 5,000 ha of forest cleared annually for new plantations. All the remaining non-commercial woods will be harvested for fuel for the wood-burning power plant adjacent to the pulp mill. 1979 is the first year that JARI will harvest all the usable wood from the natural forest before burning. Although this effectively mutes the oft-heard criticism of the burning of usable wood, the complete harvesting of wood from the natural forest may exacerbate the problem of nutrient export mentioned

earlier (p. 3). Even on the poorest tropical soils, at least one crop can be grown following forest felling and burning because the ash provides most of the nutrient capital for the crop, whether it be an annual food crop, tree plantations or even natural forest regeneration.

If the paucity of nutrients becomes a limiting factor to the growth of the second or third rotation of tree plantations on sites where most of the native trees were burned *in situ*, then the more complete utilization of the natural forest will lead to earlier manifestation of declining productivity. Nutrient-limited growth would be expected to appear first on the poorer sandy soils; this is why JARI switched to the less-demanding, slower-growing pine on the poorer sites. JARI's planting of pine on "poor" sites and melina on "good" sites should minimize the problem of nutrient-limited growth.

If nutrient export-soil fertility problems do arise at JARI I would expect them to occur in the area southwest of São Miguel now being opened up. A *caatinga*-type of native forest, only 20-30 m tall, with few large trees, but a high density of small trees with thick, leathery leaves grows on the white sandy soils. The forest and soil resemble the unusual forests on sterile white sands along the Rio Negro of Venezuela and Brazil, whose trees have characteristically high contents of complex organic compounds such as phenolics, terpenes, alkaloids, etc. The high proportion of slow-growing tree species with dense wood loaded with high-energy organics makes this type of forest a very attractive source of fuelwood. Complete harvesting of wood from this particular type of forest may so deplete the nutrient-poor sandy soil that even pine may only produce one crop before having to be fertilized or abandoned.

Plantation Establishment

The intense burn of the natural forest debris not only releases significant quantities of nutrients but has a very propitious effect on soil structure. Excellent, loose, friable structure was still quite evident eight months after burning, and most of the rainy season had already occurred. I was particularly concerned about surface erosion from the exposed soils between the time of burning and the establishment of a protective cover of plantation trees. Extensive inspection of several 1979 plantations revealed no appreciable erosion, even on some fairly steep slopes. Serious gully erosion does occur along road cuts, but though it doesn't look very nice, such erosion is insignificant when viewed over 100,000 ha of plantations.

JARI's most costly component of plantation forestry is the cleaning of weeds during the first few years of plantation establishment. Melina requires an average of four cleanings. The slower-growing pine requires more, but JARI now sows grass between the rows of pine, reducing cleanings to two. With grass in the young pine plantations the logical follow-up is to pasture beef cattle there, which JARI is doing to help supply beef for local consumption. JARI foresters found that beef cattle reduce pine growth by only 5%--quite acceptable in return for 50 kg/ha/yr of beef. Lynne and I accompanied Brick on an inspection of the damage to young pines by robust yearlings. One steer threatened us but Brick bluffed him down in Portuguese and kept him moving ahead of us by throwing sticks and branches. Not until we were back in the car did Brick tell us one cowboy had been

mauled and three horses gored by infuriated steers during the past few days.

Pulpwood Harvesting

Harvesting operations are pretty straightforward, involving the cutting of all melina trees to be harvested in a block. The high density of plantation roads facilitates loading of short pulp logs onto trucks for transport to one of the railroad depots.

I visited several areas of active harvest and did not see any serious site degradation due to harvesting, except at loading yards.

Plantation Regeneration

Because melina sprouts vigorously from the cut stump, JARI foresters expect vegetative regeneration of melina to produce two or three rotations without replanting. Even in temporary loading yards where vehicles' tires chew the bark off the low stumps, sprouts appear from the roots. Plantation workers reduce the numerous stump sprouts to the most vigorous one or two stems after the regeneration is well-established. As is typical of pioneer species, melina is a precocious tree that commences fruiting in the fourth year. Prolific production of seed is producing an excellent crop of seedlings following harvest. One stand harvested five months earlier was literally a thick carpet of seedlings one meter tall surrounding the 1.5 m clusters of stump sprouts. Such vigorous regeneration helps suppress weeds and leaves JARI foresters with the pleasant requirement of thinning the melina.

*Well-established six-month old melina plantation.*

*Gary with two-year-old melina.*

JARI does not burn the debris left after melina harvesting; thus the vigorous regeneration should minimize *in situ* nutrient loss. Studies carried out by JARI soils experts show that the appreciable soil nutrient losses associated with natural forest cutting and burning subside by the third year in melina plantations. From year three until harvest modest quantities of nutrients accrue in the topsoil. Subsequent data on nutrient fluxes following harvesting and second rotation establishment were not yet available at the time of my visit.

The levels of soil nutrients available for the second rotation should give a good indication of the sustainability of repetitive tree cropping. If soil nutrient losses following the first melina harvest reduce the soil nutrient pool to a lower level than existed in year three of the first rotation, site degradation is occurring. Lower soil fertility will decrease plantation productivity or require the addition of fertilizers to maintain productivity. On the other hand, if soil nutrient levels during the second rotation are no lower than the year three levels, repetitive tree-cropping with minimal loss of productivity seems possible.

I was impressed by the quality of the clay and sandy-clay loam soils, i.e. good melina sites, in the northern part of the forestry project area. I had expected to see the poor soils so characteristic of the non-flooded Amazonian lowlands of Peru and Bolivia. The "melina sites" of JARI look to me like they should be good for agricultural crops. Ludwig probably didn't know his property included such good soils. I wonder what Ludwig would have done if all of JARI was like the poor sandy soils around Monte Dourado. Would he have given up on melina? or on JARI? Could he have waited until 1984 for

the first crop of pine? Frankly I'm amazed Ludwig plunged into the Jari region knowing so little about the ecological requirements of melina and the major soils of JARI. I guess an 82 year-old billionaire can be lucky, too.

Plantation Problems

JARI foresters recognize the potential pest and disease problems associated with large monocultures. Homogeneous stands of a single species facilitate the rapid spread of pests or diseases. In heterogeneous multispecies tropical forests the complex ecological linkages among species generally preclude devastating outbreaks of pests or diseases. There is some ecological evidence that the number of pests on a crop is directly related to the area over which it is grown; hence JARI may expect pest problems to increase as the plantations are expanded. Nevertheless, JARI foresters accept the possibilities of pest and disease problems as economic rather than ecologic risks. This acceptance may be partly based on the very short--by temperate zone standards--rotation period of six to seven years for melina pulpwood, that would permit relatively rapid conversion to other species if some bug or pathogen started killing thousands of melina trees.

JARI foresters have monitored some minor outbreaks of melina defoliators, but found them to be quickly suppressed by natural biological controls. It is refreshing to learn JARI does not follow the typical agricultural response of rushing in an insecticide arsenal when a minor outbreak of pests occurs.

JARI does have a serious problem with leaf-cutter ants that cut leaves into small discs and carry them to their underground fungal gardens. Leaf-cutter ant colonies survive the burning to do serious damage to newly-planted melina seedlings. Some of the JARI research foresters insisted to me that leaf-cutter ant colonies occur in high densities in natural forests and simply survive the cutting and felling to continue their defoliation of whatever grows or is planted nearby. In my experience in tropical American forests I have only seen high densities of leaf-cutter colonies in disturbed forests and agricultural situations. My few days in virgin forest at JARI indicated leaf-cutter colonies to be typically scarce. I suggested the high densities in the new melina plantations may be due to the fortuitous coincidence of natural forest felling with the seasonal establishment of new ant colonies. Very few new colonies survive in virgin forest, whereas forest cutting may permit many more new colonies to survive. Brick indicated he will have some surveys of new colonies made in virgin forest and in new plantations to see if my hypothesis is correct. I suspect some basic ecological understanding of ant colony establishment and the causes of colony mortality could simplify JARI's leaf-cutter ant problem.

## General Impressions

Land Use

After several days of inured travel through the plantations we happened to pass through the pre-JARI town of Bandeira. I was surprised to see on the hillsides around Bandeira the characteristic scrub vegetation on degraded soils that is the dominant feature along the roads of lowland tropical America. Prior to JARI's arrival, Bandeira's few families harvested Brazil nuts from the surrounding forests and practiced slash and burn subsistence agriculture

on the nearby hillsides. Here it was in JARI, a microcosm of the land use problems of lowland tropical America. Slash and burn agriculturalists do not allow sufficient recovery of natural vegetation to restore soil fertility before cutting it down again, resulting in site degradation. Brick told me he had planted pine and melina on some of the degraded sites near Bandeira, but that the plantations had failed. Granted, the resources available to Bandeira's people and to JARI are at opposite ends of any scale, but even JARI could not economically rehabilitate Bandeira's degraded soils. The contrast between the productive plantations of JARI and the degraded hillsides of Bandeira is so striking it should be documented by competent soil scientists.

*Scrub vegetation on degraded hillside near Bandeira, a pre-JARI town.*

Experimental Forestry

On our tours of plantations Brick stopped frequently to point out some of the numerous experiments being done by JARI's research foresters. JARI foresters had to determine the most appropriate plantation silviculture for melina, hence an abundance of experimental plots devoted to spacing, thinning, weeding, pruning and harvesting studies. Other experiments are directed at improving the control of leaf-cutter ant colonies, the intercropping of food crops such as manioc (yuca) in the young melina plantations, pasture grasses in the pine plantations, and leaving large Brazil nut trees over the melina.

JARI foresters are definitely not wedded to melina, for more than 30 species have been experimentally planted at JARI, but none does better than melina and Honduran pine on the major soils of JARI. Brick's first afternoon tour for us continued as dusk fell, but he wanted to show me a recent

species trial. By the time we had walked into the experimental plot it was so dark I could only make out differences in height of the species so I had to ask Brick to tell me the species involved. *Eucalyptus deglupta* is doing very well and will soon be planted on a small commercial scale, not because it outshines melina but due to strong Japanese demand for eucalyptus pulp.

*Nine-year-old melina plantation left for saw timber.*

*Harvesting seven-year-old melina pulp wood.*

Conservation

JARI tree plantations are projected for 200,000 ha (494,000 acres) which is only one-eighth (12.5%) of the total property. I was very surprised to see substantial areas of good forest in the vicinity of Monte Dourado; JARI does not put plantations on steep slopes and the topography around Monte Dourado and Planalto is very broken. Company policy is to rigorously comply with all Brazilian laws, including the 50% forest reserve. On a large composite aerial photograph Brick showed me a forest block of 250,000 ha in northwestern JARI that will be left completely untouched. The area will have no penetration roads and it is upstream of the rapids on the Parú River, so human influence should be negligible. Brick also told me most of the area south of the Caracurú River will be left untouched due to steep topography, poor soils and extensive *Mauritia* palm swamps.

My favorite area in JARI is the northern perimeter road after km 48 where a 20 km stretch of road passes through beautiful virgin forest. Entrance to the forested section of road is blocked by a locked gate to keep out commercial hunters. On our first visit to this forest Lynne caught a glimpse of a tapir. Two days later six elegant helmeted curassows--a tropical wild turkey--casually strolled across the road in front of us. On our next to last day we surprised a puma sunning itself on the road.

The forest along the perimeter road is exceptionally tall, imparting an inspiring cathedral-like impression. It is the first tropical American forest I have seen with a truly emergent tree species. *Dinizia excelsa* (Mimosaceae) attains two meters in diameter and more than 55 m (180 ft) in height and consistently protrudes above the general forest canopy at about 40 m. The perimeter road is also very rich floristically, where in only five days I counted 175 species of trees.

The JARI project has important ramifications for not only the rational use of tropical forests but also for conservation. JARI's successful venture--and I do consider it a success--into tropical tree farming will undoubtedly stimulate others, particularly large timber companies, to follow JARI's pioneering efforts, just as some conservationists predict. Although I was aghast a year ago when a Brazilian told me what his country really needs are 50 more Ludwigs, the suggestion no longer is that far-fetched. In the long run conservation of tropical forests may be enhanced by the JARI project for several reasons. First, it is unconscionable and ridiculous to "lock up" the Amazon Basin. Regardless of the great species richness of tropical forests or the scare tactics about carbon dioxide release to the atmosphere and the Amazonian forests acting as the earth's source of oxygen (see GSH-7), the Amazon forests <u>will</u> be opened up for colonization and development. Many grandiose schemes, such as Henry Ford's rubber plantations at Fordilandia and even Brazil's Amazonian colonization projects have failed. The failure of JARI's tree farming project would obviously scare away all interests in plantation forestry in the Amazon. About the only recourse left for the Brazilian government would then be to open the Amazonian forests to the rapacious timber companies now mining the forests of Southeast Asia.

*Impressive trees in virgin forest along the north perimeter road. The large tree on the left is* ***Dinizia excelsa*** *(Mimosaceae) and the partially obscured tree on the right with very large buttresses is* ***Huberodendron sp.*** *(Bombacaceae).*

But if JARI's tree-farming project succeeds, it becomes a powerful model for tropical forestry. On appropriate soils tropical foresters will be able to produce appreciable volumes of timber or pulp on a sustained yield basis. Such opportunities could greatly increase the yield that in turn could have a positive effect on diminishing the necessity to log tropical forests. It seems to me conservationists would be wise to stop "knee-jerking" about JARI's deforestation and start working for strengthening and enforcement of Brazil's 50% law. We know that large tracts of forest are more effective conservatories of species than are small patches, so some possible reforms might stipulate: a minimum holding of one million hectares; two blocks of forest reserve must each comprise not less than 10%

of the entire property; the owners be responsible and held accountable for protection of the two major blocks of forest reserve; and legal constraints on "halving" the 50% in forest reserve.

If management systems for natural tropical forests are not soon developed, I don't see much hope for the survival of natural forests outside of national parks. With the capability to use all the wood in the natural forest, JARI is an ideal situation to develop innovative management systems for sustained production from natural forests. JARI foresters are now starting to consider the possibility of managing natural forests. I hope JARI will soon embark on the necessary experiments with management systems and will have success comparable to their advances in plantation forestry.

JARI Integration and Innovations

Of all the unique or mind-boggling aspects of JARI, I am most impressed by the numerous innovative efforts to achieve a highly integrated operation. JARI is striving to attain 80% self-sufficiency in basic food commodities, including fruits and vegetables plus the staples of rice, beans, manioc and beef. In addition to the previously mentioned pasturing of beef cattle in young pine plantations, JARI has also developed major hog and pountry operations. Over 3,000 head of water buffalo are pastured in the herbaceous marshes along the Amazon.

Melina logs must be debarked before entering the pulpmill. The bark could be used for fuel, but JARI is testing chipped melina bark as cattle fodder. Except for a small addition of molasses to make the melina bark palatable, a strict diet of melina bark has produced a half kg/day weight gain in penned steers over a three month test.

In my opinion, Peter, Brazil is the world's leader in developing economic alternative energy sources to substitute for petroleum. All the gasoline in Brazil contains 20% alcohol. In São Paulo, 1,000 test vehicles have been using 100% alcohol in place of gasoline for more than a year. JARI is presently evaluating plans to plant 4,000 ha/yr of manioc to use as a source of alcohol that will replace virtually all the gasoline used in JARI.

Many of these experiments and innovations were conceived and tested by Brick. He deserves considerable credit for the progressive advances JARI has made and is making in plantation forestry in the tropics. He and his wife, Jan, were also most gracious and helpful hosts to our very enlightened and productive stay in JARI.

In sum, Peter, I entered very skeptical about JARI's tree-farming operations and possibilities for success, but left 10 days later convinced JARI will succeed and most impressed with the company. One can only marvel at the foresight and verve of Daniel K. Ludwig in conceiving and developing JARI.

Sincerely,

Gary

Gary S. Hartshorn
Forest & Man Fellow