Settlement in the Humid Tropical Life Zones of Latin America

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INTRODUCTION

Flying into the valleys of Cali, Quito, or Cajamarca, one observes ample ranches, dairy farms, and fields of grain and sugarcane. One sees also the minifundia that give rise to the migrants: four moving to the cities for every one to the frontier. This study analyzes migration to the tropical frontiers, in full knowledge that the fate of the migrants is interwoven with that of the 75 percent of the Latin Amerrican population expected to be living in cities by the turn of the century (United Nations 1980). This urban population will place unprecedented demands on the natural frontier base for food, forest products, water, and hydroelectric energy, while at the same time competing with the frontier zones for scarce national development funds.

Migration to the agricultural frontiers of the huumid tropics occurs because of a decline in well-being in the home region--push factors--or the perceived attractiveness of new lands--pull factors. Occasionally the push is dramatic as in the case of political upheaval and rural violence or a major drought. Migration is more often a response to the slow but inexorable pressure of a growing population on a degrading resource base. The pressure may be the result of (1) deeply rooted tenure patterns that have long prevented access to more inherently productive land (Crist 1983); (2) of inherited culltural attitudes toward the land and its management (Dickinson 1981); or (3) of the incapacity or unwillingness of governments to extend to *campesinos* appropriate agricultural technology, credit, marketing assistance, and social services including eduucation, health care, and family planning.

Much of the pioneer settlement of the humid troppics to date has resulted in only ephemeral increases in economic production, achieved all too often through a decapitalization of the tropical resource base that results merely in an extension of rural poverty to new areas. The traditional grain and pasture agriculture of the drier zones is ill adapted to the moist and wet tropics. Government ability to deliver services to the humid zones is further limited by poor roads, dispersal of migrants, and conditions of heat, humidity. and isolation unattractive to agents from the capital. Enough is now known about tropical resource management and the settlement process to achieve sustainable development. No composite model exists, but a critical mass of discrete experiences can be drawn upon by interdisciplinary development teams and adapted to local circumstances.

Elements of two distinct options are open to pollicy makers seeking to increase agricultural productivity in tropical Latin America. The first is to promote the concentration of small- and large-scale commercial agriculture on the potentially most productive lands with ready access to urban markets and sources of services--the intensification option. The second is to promote the full occupance of all national territory, much of which is situated in the moist and wet tropics, and the utilization of all resources, even those at the ecological and economic margins--the frontier settlement option.

ECOLOGICAL FACTORS AFFECTING POPULATION DISTRIBUTION

Where people have settled can be defined in terms of ecological "Life Zones" (Holdridge 1967). These units are based on simple climatic parameters, including mean annual temperature, precipitation, and potential evapotranspiration (PET) (Figure 1). The Life Zone concept is employed in human ecology to define land capability for various uses including agriculture. Much of the ensuing discussion revolves around the location of a particular Life Zone relative to the' 'unity line" labeled in the Figure. Unity refers to the 1:1 ratio between precipitation and evapotranspiration. Moving to the left of the line, Life Zones are increasingly arid (evapotranspiration exceeds precipitation by ratios of 2, 4, etc.); to the right of the line humidity increases, potential evapotranspiration (PET) being only a fraction of precipitation ratios of 0.5, 0.25, etc.

People have tended to concentrate where climate, soil, and topography combine to create desirable **[end p. 34]**

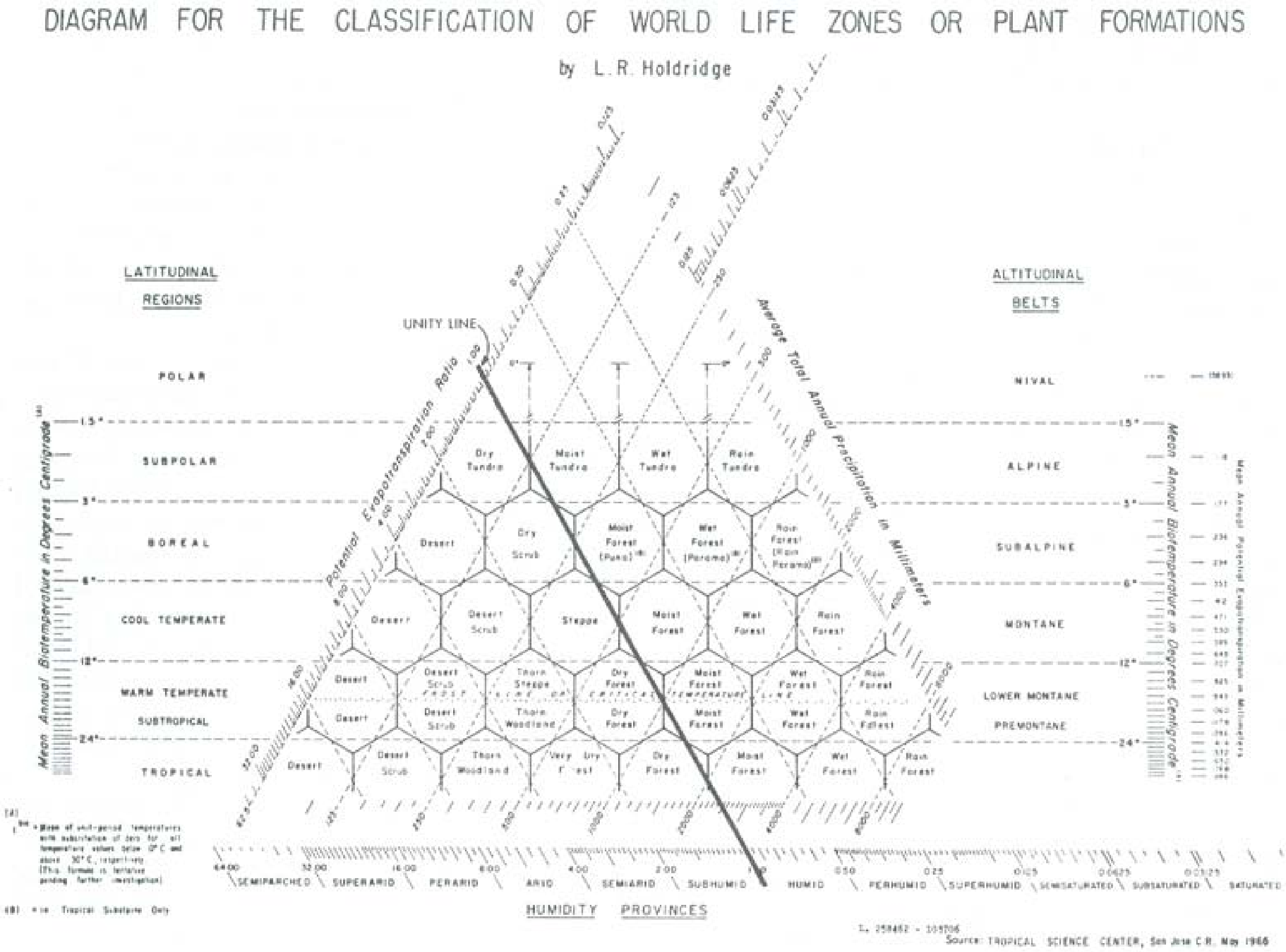

Fig. 1. World life zones.

conditions for urban and agricultural development. Some 80 percent of the Latin American population is found in cities, in intermontane valleys, river floodplains, and coastal plains, which receive 500 to 2000 mm of rainfall per year and which are located between sea level and nearly 4000 m elevation (Economic Commission for Latin America 1979). Looking at the Life Zone diagram in Figure 1, one sees that most of this population is concentrated in the parts of the zones closest to "unity line" where rainfall and evapotranspiration are nearly equal. Lower Montane and Montane Moist Forest and Dry Forest/Steppe Life Zones are closest to the unity line. Only two capital cities in Latin America, Lima and Santiago, are located outside this climatic band. In both cases, the cities are in drier Life Zones with exotic streams providing adequate water for urban development and agriculture (Holdridge 1967, 16).

Traditional European and modem high-input agricultural systems tend to be easier to sustain near the line, especially on the drier side, than in more humid areas. Much of this land, unfortunately, has steep slopes and concentrated population, which create a potential for rampant erosion. In Ecuador, for example, 33 percent of total agricultural production, excluding coffee and subsistence crops, comes from steep lands. The figure is 26 percent in Colombia, and in Peru, with its irrigated coastal valleys, 19 percent (Posner and McPherson 1982).

THE AGROECOLOGICAL CONTEXT

The Drier Life Zones.

Arid areas have been the scene of both failure and success in agricultural development. Sporadically deficient rainfall results in crop failure. Grazing and firewood cutting is commonly carried out at levels in excess of the recuperative capacity of the natural ecosystems. Rainfall that does occur is often "aggressive," coming in violent thunderstorms with resultant heavy erosion of lands bared by overgrazing and cultivation. Life Zones with PET ratios between 1.5 and 2.5 in Figure 1 have been the traditional source of the most desperate migrants. Because of the historical land tenure inequalities, peasant farmers have limited access to the more level, better watered, and fertile lands. **[end p. 35]**

Areas suitable for irrigation have been made highly productive. In Mexico, for example, 80 percent of the increase in agricultural production during one period in the sixties took place on less than 4 percent of the production units, mostly in the irrigated north (Dourojeanni 1980). Much of the success in expanding irrigation is dependent on high levels of organization, technical skill, and capital investment. In Peru, for example, poor water management has resulted in salinization affecting the productivity of more than 30 percent of the fertile irrigated coastal lands. The rate of increase of lands affected by salinization matches or exceeds the rate of gain of land to agriculture through costly irrigation projjects (Dourojeanni 1980, 105). Advances in agriculture in the dry tropics have been achieved largely by overcoming physical stress: the lack of sufficient moisture to grow crops. Given water for irrigation and suitable soils and topography, mid latitude technology in agronomy, water management, and inntegrated pest management can be effectively applied.

Life Zones Flanking the Unity Line.
Optimum conditions for rainfed agriculture are found when PET approximates precipitation. There is adequate rainfall for at least one crop per year and neither salt accumulation nor leaching are a serious problem. The dry season is analagous to the mid-latitude winter, a die back of pests and weeds occurs, oxidation of organic matter slows down, and minerals leached into the subsoil tend to return to the upper soil horizons as soil moisture evaporates. In the lowland tropics rainfall along the unity line between Dry and Moist Forest Life Zones ranges from 1500 to 2000 mm. Rainfall on the unity line is 500 mm at 3500 m elevation. Crops adapted over the entire range of altitudes can be grown: plantain, cassava and avoocado, and many others in the lowlands, and potatoes, quinua (i>Chenopodium), and a few mid-latitude crops at the 3500 m level. It was at these higher elevations in the intermontane valleys of the Andes that the Spaniards found conditions for living and agriculture similar to Iberia. As in the case of irrigated dry lands, midlatitude technology could be applied in the higher unity line Life Zones with relatively few limitations. The major problems have resulted from the conversion of land once dedicated to food crops into extensive pasture land for sheep and cattle and the substitution of exotic crops, such as long day length, mid latitude wheat varieties, for the highly nutritious, locally adapted quinua.

The Wetter Life Zones.
The primary challenge in the humid tropics has been to overcome biological competition; year round competition between crops, including pastures, on the one hand, and weeds and pests on the other. The traditional agriculturist has historically employed two strategies in keeping with his limited resources to produce food. One is shifting agriculture, which uses fire to release nutrients and kill back weeds and pests, permitting several harvests before competition becomes unacceptable. The other is the intensively managed garden, which imitates the structure and diversity of successional forest. In Asia, farmers routinely incorporate a detritus-based fish pond subsystem in their garden sysstems. Conventional crop and pasture monocultures have been difficult to sustain at high levels of prooductivity in the more humid tropics.

. On the right -hand side of Figure 1, Wet Forest and Rainforest Life Zones are found at all elevations. At altitudes above 1000 m, these Life Zones occur in relatively narrow bands along the steep eastern slopes of the Andes. Lowland Wet Forests are very limited in extent with the dominant Life Zone being the Tropical Moist with rainfall averaging closer to 2000 mm than to the upper limit of 4000 mm at the margin of the Tropical Wet Forest. As the PET ratio decreases from 0.7 toward Rainforest conditions of 0.25 to 0.125, the problems of biological competition become all the more severe, as do the problems of soil management. The principal limitations are summarized below:

1. The growing season extends throughout the year for both crops and for pest and disease organisms as well as for competing weeds. Conventional control measures are increasingly costly and ineffective.

2. In addition to erosion and mass movement of soils exposed to heavy rainfall, extensive areas of soils with low cation exchange capacities are subject to chemical degradation, owing to leaching and oxidation of organic matter. Grazing results in further degradation owing to compaction of soils. Fertilizers applied are rapidly leached out, physically removed in runoff, or rendered chemically unavailable to crops (Food and Agriculture Orgaanization of the United Nations 1979, 19). The incidence of aluminium toxicity is high.

3. The very humid tropical forest is rich in plant nutrients that are found primarily in the living biomass. An efficient root system rapidly recycles nutrients from dead organic matter back into the above-ground living component. Clearing for agriculture and pasture results in rapid loss of nutrients from leaching, runoff, and volitation.

4. Because the very humid tropics have not been attractive to settlement in the past, there is only limited infrastructure in the form of roads or facillities providing health care, education, research, exxtension, and marketing services.

Development administrators must recognize that the humid tropics require a radical departure from traditional midlatitude approaches to resource mannagement if sustainable development is to be **[end p. 36]** achieved. The forest products industry has developed uses for only a small fraction of the tree speecies. Screening of organisms for medicinal and other uses is promising but slow (Wilson 1984; Meyers 1983). Indigenous cultures have evolved sound management practices that are relevant to modern development needs. Although widely documented, these practices have yet to be effectively incorporated into extension practice (Clawson 1985; Dickinson 1972; National Research Council 1982; and International Union for the Conservation of Nature 1975).

TYPES OF SETTLEMENT

The settlement process ranges from the spontaneous migration of individual families to recruitment and settlement schemes totally directed by government. Settlement in Amazonia and elsewhere historically has followed rivers, taking advantage of the ease of riverine transportation and the relatively sustained productivity of floodplain alluvial soils. In recent decades the bulldozer has provided the means for opening roads through the tropical forest. In some cases roads have been built to provide settlement access, but more often other goals were parramount with spontaneous settlement being incidental. These goals have included timber extraction, petroleum exploitation, national defense, and the linking of urban centers. The high cost of bridging large floodplain rivers assures that highhways will follow the interfluvial uplands as much as possible, thus avoiding rather than connecting the areas of better soils.

Government services for spontaneous settlers eventually follow the opening of a new road. Planned colonization projects generally involve the anticipation of the needs of selected settlers reecruited elsewhere in the country. A notably generous example was the Altamira project, part of Brazil's Trans Amazonian highway program, which offered settlers 100 hectares of land, six months of salary, housing, primary and secondary roads, credit, and marketing services (Moran 1982). It has been found in Bolivia that the spontaneous settlers attracted to subsidized colonization projects have been more successful than the intended beneficiaries because of their higher level of motivation, lack of a debt burden, and freedom to choose better soils rather than being restricted to arbitrarily assigned lots (Stearman, personal communication).

Intermediate in the level of government involvement between highway-related spontaneous settlement and directed colonization has been what could be called semi-directed settlement. The government anticipates certain needs of spontaneous settlers, providing assistance in land titling, extension, credit access, and feeder road construction. Government assistance occasionally has had unanticipated negative consequences such as in Bolivia and Peru where, to the embarrassment of the national govvernments and international donors, highways constructed in the Andean piedmont for the avowed purpose of opening new areas for settlement stimulated, instead, the cultivation of coca for the international cocaine trade.

Independent from the settlement types mentioned above are the modem plantations exemplified by bananas and, more recently, oil palm. Profitability is predicated upon low labor and land costs as well as upon a lucrative export market that can support heavy investment in fertilizer, pesticides, extensive transportation systems, and elaborate handling and shipping facilities. The availability of chemical ferrtilizers has reduced the importance of natural soil fertility of plantation lands while increasing the value of good soil structure for mechanical operations. These highly developed enclaves, or "factories in the field," are irrelevant to the *campesino* with his limited resources.

SETTLEMENT VIABILITY

In a thorough study of 24 cases in the Latin American tropics, Nelson (1973) observed that "failure is directly related to the degree of government innvolvement in a project, transport costs, and the degree of pioneer colonization involved relative to consolidation with peripherial expansion into new areas," and further that "evidence is on the side of those who would restrain expansion in the hope that higher returns would result from a sequence that places initial emphasis on consolidation, education, the accumulation of knowledge, and improvement in public administration. The prudent approach to movement into pioneer areas is a gradual one deesigned to attract spontaneous settlers and, within the limits prescribed above, private investment and ennterprise" (Nelson 1973, 265, 291). The wisdom of Nelson's observations has been amply demonstrated in Brazil where the costly failure of directed colonization has been exhaustively documented (Wesche 1983; Moran 1982; and Smith 1981).

It is estimated that only 6 percent or one hectare in fifteen of the Amazon Basin has soils of even moderate fertility (Sánchez 1982, 822). This 32 milllion hectares is roughly equal to the arable land base of Peru but is spread over a 484 million hectare area, mostly in alluvial deposits of limited extent. The failure of the massive Trans Amazonian Highhway settlement project in Brazil was closely linked to the limited areas of fertile soils and to the excessively high cost of providing inputs, services, and marketing support for farmers scattered along **[end p. 37]** thousands of kilometers of road. Had settlement followed rivers rather than lines on the map, a much higher proportion of good soils (and pre-existent settlement) would have been encountered at a connsiderably lower cost.

Among the various inappropriate justifications for directed colonization has been a desire of international multilateral and bilateral development institutions and governments to have projects that facilitate auditing and control and produce clearly identifiable results. Nelson (1973) identified some of the chronic problems that tropical settlement has faced because of deficiencies in public administration. He advocated a gradual approach to expanding the settlement frontier. This makes sense in terms of soils and ecological considerations as well.

It can be assumed that almost all of the inherently fertile soils of tropical America have been fully occcupied. These include arid lands suitable for irrigation, the cooler intermontane valleys and, in the more humid lowland tropics, alluvial material from the Andes and outcrops of terra roxa soils and basalt. Most migration to date has been to sites with poorer soils relative to the undegraded state of the place of origin. Occupation of a new settlement zone in no way implies, however, that anything approaching optimal agricultural output has been achieved, owing to the fact that the new settlement regions are planted to extensive cattle pasture, to crops only marginally suited to the Life Zone, or are beyond effective access to services and markets.

Given limited personnel and budgetary resources, anticipated return on investment in frontier colonization should be compared with alternative development strategies. Major increases in well-being and productivity could be achieved through soil connservation, redistributing land, and providing production incentives in settled areas where an overall service infrastructure already exists. In some countries more efficient use of irrigation or even the exploitation of new sources of surface or subsurface water could greatly increase the productivity and carrying capacity of heretofore sparsely populated arid areas. In Peru, irrigation water is inefficiently used and subsurface water is virtually untapped.

AGRICULTURAL MODELS

In the Latin American tropics both historic settlements and better soils are concentrated along the unity line. Descending the unity line into the lowwland tropics, soils tend to become poorer as the rate of organic matter oxidation increases at higher temperatures and as higher rainfall results in physical removal of soil nutrients from tilled land. The campesino's accumulated experience during centuries of living in uplands as well as the unmodified technology introduced from the temperate latitudes become decreasingly appropriate. These are the ecological factors supporting Nelson's recommendation of caution and the accumulation of knowledge and experience by settlers and the institutions responsible for research and extension. The problems of sustaining agricultural production become all the more formidable as the settler moves away from the unity line in Figure 1 into the wetter Life Zones.

The challenge in the humid tropics has been to overcome biological competition, not physical stress. The agricultural strategies used are fundamentally different; one revolves around soil mannagement and the other, ecosystem management. In the midlatitudes and higher elevations in the tropics, the majority of the nutrients are in the soil. In the lowland humid tropics the opposite is the case: most of the nutrients are in the above-ground biomass of the forest. When whole systems are compared, dry and wet Life Zones may be equally rich in nutrients. What is important in management is where the nuutrients are concentrated.

Peoples indigenous to the humid tropics have evolved various techniques of surviving. These techniques are imitated, usually in a much degraded form, by migrants. One is shifting agriculture and the other is the intensively managed dooryard garden. Indigenous peoples depend primarily on hunting and fishing for protein. Migrants depend more on domestic pigs, chickens, and ducks. Such agricultural systems can sustain a high level of subsistence security, but at a relatively low population density with only limited potential for crop export without outside subsidy. Such systems are distinguished from those adapted to the dry side of the unity line by exploitation of nutrients in the vegetation (shifting agriculture) or imitation of the nuutrient conservation strategies of the diverse forest (dooryard garden).

Cattle production may be the single most destrucctive human activity in the tropics of America. Near the unity line ranching perpetuates the control of extensive areas of potential crop land by a small elite. In the humid tropics, the perpetuation of an Iberian heritage and national and international marrkets for beef result in continual expansion of the pastureland frontier. Intermediate activities may be timber extraction and shifting agriculture.

The opportunity cost associated with cattle raising is high. Export production is achieved through decapitalization of the forest resource. The extensive cattle ranching found throughout Latin America has reduced timber production that could result from managed forests, has lowered the level of nutrients stored in the biomass, reduced the output of minor forest products such as medicinal plants, and de- **[end p. 38]** pleted the natural flora and fauna utilized by indigenous peoples. Maintaining a fixed cattle population in the lowland tropics often requires expansion of the land base due to rapid pasture degradation. The human carrying capacity of the land is reduced owing to both the large size of the holdings and to the relatively low productivity per unit area. Given the time lag in the arrival of roads, government services, and appropriate technology, selective lumbering, shifting agriculture, and ranching have unfortunately been the only widely known means of achieving subsistence or immediate income from the humid tropics.

Three land management models exist that have demonstrated a capacity to generate sustained, long-term agricultural production from the humid tropics. The first is the "Yurimaguas model," which is based on tropical soil management studies in eastern Peru. It involves three annual crop cycles a year using high levels of inputs and sophisticated techhnology.

The second is the Costa Rica-based Tropical Science Center system of sustained forest production based on total wood utilization in narrow strips followed by natural regeneration. It would be operated by individual families or small communities with a central wood product processing facility. The third model is a composite system combining elements of the above concepts as well as technology adapted from agroforestry research and successful indigenous practices. This farm systems perspective proovides an integrative structure. All three models are dependent on a good transportation system, effective public administration (principally secure land titles), and access to efficient government services. All are dependent to varying degrees on outside inputs including agricultural chemicals, machinery, and fuel.

The Yurimaguas Model.

More than a decade of controlled experimentation in the upper Amazon Basin in eastern Peru has demonstrated the productive pootential of relatively infertile but well structured tropical soils under intensive IT management (Saánchez 1982). Yurimaguas lies just on the humid side of unity line on the Life Zone diagram marking the division between dry and humid climates. Average yields were between 2.3 and 3.46 tons per hectare for rice, com, soybeans, and peanuts, with a combined yield of 7.8 tons per hectare over a year of continuous cropping. Three tons of lime were appplied every three years, 80 to 100 kg of nitrogen to corn and rice, and 25 kg of phosphorus, 80 to 100 kg of potassium, and 25 kg of magnesium applied to every crop. Traces of copper, zinc, boron, and molybdenum were applied as indicated by soil analysis to correct deficiency problems. This work demonstrates that midlatitude crops and soil management technology can be transferred to the humid tropics under close supervision by highly trained soil scientists and agronomists.

Such a model of intensification offers an attractive alternative to the prevalent process of tropical forest decapitalization, with low agricultural yields and income, resulting generally in the conversion of land to poor pasture. Were the countries of the region to develop a highly motivated research and extension service, an integrated market economy with a foreign exchange surplus, and an efficient transportation infrastructure, then the high input technology would have wider applicability. Unfortunately the settlement frontiers of the region offer few of the requisite conditions. Near major markets, particularly in subtropical and cool tropical highlands, and in areas with an irrigation tradition, the technology could find more ready application. It is on the fringe of urban centers that sophisticated and productive entrepreneurs are operating today. Because the system is dependent more on the integraation of technology and production inputs than on adaptation to a particular set of ecological constraints, governments can promote the technology where circumstances permit.

The Tropical Science Center (TSC) Model.

The TSC approach is based on the assumptions that sustained yield forestry can be an economically viable use of the tropical forest and possibly the only sustainable use of the Wet Forest Life Zones. It is based on the novel concept that forestry can be carried out at the scale of individual family or community management units feeding into a central processing facility.

Under this system, relatively narrow strips are successively cut through mature forest each year, always leaving mature forest next to the newly cut strip as a source of seed. All timber is transported to the roadhead by teams of animals, leaving the strip bare as a seed bed for the relatively light, wind dispersed seed of many of the more valuable timber trees that pioneer naturally in light gaps created in the forest by falling trees. All the cut timber is used, either for lumber, furniture, poles, craft work, charcoal or firewood.

The system requires heavy initial investment in wood processing equipment. Beyond equipment maintenance, the system requires minimal expenditure, but considerable labor to prepare areas for felling, cutting, hauling, and the cleaning and cullling of strips in successional growth. A cutting cycle of about 40 years is anticipated, with 10 hectare strips cut each year in a management unit of about 400 hectares.

A commercial demonstration of the system is being conducted in the Palcazú Valley of Peru by the Tropical Science Center under the Agency for International Development funding (Tropical Science **[end p. 39]** Center 1982). A family holding of 400 hectares appears large. In the area selected, with 6,000 mm of rain, leached high aluminum soils, and broken topography, no other legal use has a higher per hectare economic return. To be successful, considerable discipline is required, both by the landowner in maintaining the cutting cycle and by the state to protect the property from invasion.

While the system is unprecedented and therefore risky, it is based on solid experience in forest ecology. Given the record of wasteful forest exploitation and conversion of potentially valuable forest lands into poor pasture, this concept deserves a thorough test. One advantage is that this management strategy preserves the greatest number of options in land use should superior sustainable uses subsequently be discovered.

The Composite Farm Systems Model.

The farm sysstems model is based on several socioeconomic, technical, and ecological assumptions. Basic among these is the assumption that in a developing country the capability of government and the private sector to deliver goods and services in support of agriculture is deficient, particularly at the frontier margins. This precludes high levels of inputs to campesino agriculture. Agricultural systems must be ecologically engineered to imitate useful characteristics and processes in natural systems.

More than three quarters of the Amazon Basin, excluding the sandy soils, has a rather high nutrient status per hectare if the minerals contained in the living biomass are included (National Research Council 1982, 57; Odum 1975, 105). Traditional dooryard gardens (Denevan 1984) and scientific appproaches to agroforestry are designed to imitate the mineral cycling and conservation of the humid troppical ecosystem. This moderately productive alterrnative has the advantage of being adaptable to a wide range of ecological settings and levels of innputs. Such production systems rely more on longer cycle crops than annuals.

Multiple cropping of short cycle annuals requires comparable investments in fertilizer, pesticides, fuel, and labor for each crop (Sánchez 1982). Annual yield is comparable if not higher in the midlatitudes with only one crop because of the longer day length and lower night time respiration. Longer cycle crops, including yuca, taro, plantains, and sugarcane, produce many more calories per hectare per year than do corn or other grains because they capture solar energy continuously over a longer period (Cock 1982). There is no inherent reason why fertilizer and genetically improved germplasm cannnot be used to increase yields. With labor intensive cultivation and harvesting it is not necessary that crops be planted in single species rows. The forest products industry has developed uses for only a fraction of the species found in the tropical forests. Potentially even greater benefits can be derived from much of the tropical forest in situ in the form of medicinal plants, animals, water conservation, geenetic research, and recreation (Myers 1983).

Emphasis should be given to animal protein production integrated with the overall agricultural production scheme. The basic goal is to find alternatives to total dependence on extensive cattle production. Swine are particularly strong candidates for utilization of crop residues, unmarketed crops, and crops grown specifically for feed. Experience is being gained with use of pasture-legume mixtures for cattle combined with valuable timber trees.

A tropical farmer may plant annual crops, practice intensive horticulture, small and large animal husbandry and silviculture, extract forest products, hunt, fish, and process goods for market. The needs of such farm families are not served by specialized commodity programs geared to the needs of large enterprises. The farming systems approach has promise of improving the economic lot of a large segment of the region's society and increasing production as well. The focus should be on ecologically adapted cropping systems, the organization and management of the individual farm unit, and on the structure and appropriateness of government suppport.

LESSONS FOR SETTLEMENT AND DEVELOPMENT

We may conclude that settlement of frontier lands is not necessarily synonymous with development. Government efforts to promote settlement, particularly through directed colonization, have been generally unsuccessful and expensive. Resettlement to relieve poverty in core areas usually results in the spread of poverty. The Trans Amazonian highway program succeeded in resettling less than one percent of the target Northeast Brazil population (Smith 1981, 755). Resettlement is not an alternative to resolving core area inequities in land tenure or acccess to basic government services such as health, extension, and credit.

Settlement in the lowland humid tropics is inevitable, although the Wet Forest and Rainforest Life Zones should be avoided except for very special uaes. If settlement is to result in actual qualitative development, a net improvement in human wellbeing, then planners should consider the following guidelines:

1. The potential of the target area should be asssessed utilizing existing climatic data and geomorphological interpretation of maps, aerial photography, and satellite imagery coupled with field reconnaissance drawing upon local knowledge **[end p. 40]** of the area (Holdridge 1967). Given the potential for unanticipated problems, more costly detailed studies should be undertaken on an incremental baasis for areas actually being developed (Nelson 1973, 183).

2. The organizational, technical, and financial capability of government to undertake a project should be assessed. The motivation and morale should also be considered. The scope of the project should be geared to overall capability.

3. Both the target and affected populations should be identified. The experience and proven capabilities of potential migrants should be evaluated in light of the conditions found in areas where colonization is to be encouraged. Where cultural differences exist between migrants and people already in the area, the implications of these differences should be assessed. The land requirements and cultural integrity of indigenous peoples should be respected. The resource management practices of these people may provide highly valuable models for new settlers.

4. With reference to the Life Zone concept, migration should be encouraged within a given environmental type, rather than

promoting traumatic changes where landuse is likely to be unfamiliar and adverse health and comfort effects encountered. Ideally a project should be adjacent to and compatible with established settlements.

5. Rather than laying out a rigid grid, development should be selectively focused on the best soils as determined by local experience as well as by formal survey. It has been found that a geomorphological survey can yield more useful information on potential land use than can a soil survey of equivalent cost (Dickinson 1982, 323). The size of individual holdings should be determined by land capability and resources available to the farmer rather than by some predetermined policy. The tiitling of land should be encouraged and granted expeditiously.

6. A farm systems approach should be applied but with a balanced cultural, ecological, and microeconomic perspective.

7. Serious consideration should be given to the development value of the tropical forest as a forest, both as a renewable source of timber and in situ as a source of water, for science and medicine, tourism, and recreation.

8. Because many of the values of the tropical forest benefit and are appreciated by all the world's people, mechanisms should be sought to allow the world community to compensate in perpetuity the tropical peoples for not converting these intrinsically valuable tropical ecosystems into ash to grow corn and pasture.

REFERENCES CITED

Cawson, D. L. 1985. Small scale polyculture: An alternative development model. *Philippine Geopraphical Journal* 29 (3&4): 1-12.

Cock, J. H. 1982. Cassava: A basic energy source in the tropics. *Science* 218:755-62.

Crist, R. E. 1983. Land for the people-A vital need everywhere. *The American Journal of Ecoonomics and Sociology* 42(3): 278-83.

Denevan, W. E., .T. M. Treacy, J. B. Alcorn, et al. 1984. Indigenous agro-forestry in the Peruvian Amazon: Bora Indian management of swidden fallows. *lnterciencia* 9:346-57.

Dickinson, J. C. 1972. Alternatives to monoculture in the humid tropics of Latin America. *The Professional Geographer* 24 (3):217-22.

Dickinson, J. C. 1981. Una perspectiva ecológica sobre el desarrollo. *Interciencia* 6(1): 30- 3 7.

__________. 1982. Development planning at the interface of mountain and plain: A Venezuelan case study. Mountain Research and Development 2:317-26.

Dourojeanni, M. J. 1980. *Renewable natural resources of Latin America and the Caribbean: Situation and trends.* Washington, D.C.: World Wildlife Fund-U.S.

Holdridge, L. R. 1967. *Life zone ecology.* San José, Costa Rica: Tropical Science Center.

MCN. 1975. See International Union for Conserrvation of Nature and Natural Resources.

International Union for Conservation of Nature and Natural Resources. 1975. *The use of ecological guidelines for development in the American huumid tropics.* MCN Publication New Series No. 31. Morges, Switzerland: mCN.

Moran, E. F. 1982. Colonization in the Transamazonia and Rondonia. Third Annual Latin American Conference on Frontier Expansion in Amazonia. February 8-11, 1982.

Myers, N. 1983. Tropical moist forests: Overploited or under-utilized? *Forest Ecology and Management* 6:59-79.

National Research Council. *Ecological aspects of development in the humid tropics.* Washington, D.C.: National Academy Press.

Nelson, M. 1973. *The development of tropical lands: Policy issues in Latin America.* Baltimore: Johns Hopkins University Press for Resources for the Future, Inc.

Odum, E. P. 1975. *Ecology.* 2d ed. New York: Holt Rinehart and Winston.

Posner, J., and M. McPherson. 1982. Agriculture on steep slopes of Latin America: Current situation and prospects for the year 2000. *World Development* 10:341-52. **[end p. 41]**

Sánchez, P. A. 1982. Amazon basin soils: Management for continuous crop production.*Science* 216:821-27.

Smith, N. J. 1981. Colonization lessons from a tropical forest. *Science* 214:755-61.

Stearman, A. M. Personal communication.

Tropical Science Center. 1982. *Sustained yield management of natural forests.* Project No. 52770166, Consultant Report prepared for USAID. Lima, Peru.

United Nations. 1980. *Patterns of urban and rural population growth.* United Nations Population Studies, No. 68, New York: United Nations.

United Nations Economic Commission for Latin America. 1979. *Water management and enviironment in Latin America.* New York: Pergamon Press.

United Nations Food and Agriculture Organization. UNEP/UNESCO. 1979. *A provisional methodology for soil degradation assessment.* Rome: FAO.

Wilson, E. O. 1984. *Biofilia.* Cambridge: Harvard University Press.

Wesche, R. J. 1983. Transporte, organización espacial y logros en los proyectos de colonización de la región Amazónica brasileña. *Revista Geográfica* 98:44-53. **[end p. 42]**