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Forest to Pasture: development or destruction?

by

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Abstract: The expansion of artificial or planted pastures (*repasto*) at the expense of both natural forest and cropland has brought major changes to the landscape and economy of Central America in recent years. On the pioneer fronts at the forest margin agriculture is commonly a transitory stage between forest felling and the establishment of permanent pasture. In the past 15 years the area in planted pasture and the total numbers of beef cattle have nearly doubled in several Central American countries while the per capita consumption of beef has actually declined. The "grassland revolution" that is occuring in Central America and Panama has been based almost exclusively on grass species of African origin which have in most cases been introduced into Central America only in this century. Of these jaragua, guinea, pangola, and kikuyu are the most important. The ecologic consequences of the conversion of forest to pasture are little understood. Intensive management practices, including the application of high-cost and scarce fertilizers and carefully-managed rotational grazing, will probably be necessary to sustain the productivity of these lands under conditions of tropical climate.

Substantial parts of Central America and Panama have undergone a dramatic change of aspect in recent years, the result of accelerated forest clearing and enormous expansion in the area of artificial or planted pasture (repasto). At times it seems that the isthmus is on the way to becoming one great stock ranch. Twenty years ago the Pan American highway route passed through extensive tracts of tropical forest (27). Today its entire paved length is through cropland and *potrero*, even over its 3700 meter summit in Costa Rica. In pre-Columbian times the tropical forest zone was intensively exploited and occupied, as its abundant archeologic remains illustrate. But without livestock the American Indians had no interest in the establishment of pasture, so that their agricultural clearings, whenever abandoned, were allowed to revert directly to secondary forest or *rastrojo*.

With the depopulation of the lowlands following the Conquest, settlement became concentrated largely on the better soils of the healthier highlands and on the drier Pacific coast. This pattern of population distribution persisted more or less

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undisturbed until the 20th century. The fruit companies, so often maligned for their social irresponsibility, first showed that permanent and productive agriculture could be carried on profitably in these rainy lowland environments given capital and management skills, an adequate social infrastructure, and public health facilities.

More recently modern highways and *vias de penetración* have provided increased access to these forested lands which increasingly has attracted the overflow of landless *colonos* from the more densely settled rural areas. The growing pressures for new lands, sometimes channeled through government-sponsored colonization schemes but more often as spontaneous colonization onto government *baldíos,* have been reflected in the accelerating retreat of the forest margins towards the rainy Atlantic slope. Fig.1, adapted from that of **Sandner** (33), broadly delineates the more active pioneer zones and the extent of the remaining forest.

Conversion of *selva* to grassland continues on many fronts. The southern extension of the Isthmian highway, driving southward from Chepo into Colombia is one such in Panamá; another is along the new road being driven across the flanks of the Volcán de Chiriquí from David to Almirante Bay. The Valle de El General in Costa Rica has been almost completely converted to pasture and crop land in less than twenty years, and the same process is well along in the Coto Brus. Similarly, the cattle people have been moving in on Puriscal and Turrubares, onto the San Carlos, the Sarapiquí, and the Arenal fronts, and elsewhere in the more humid parts of Costa Rica (32). In Nicaragua, the opening of the Rama road led inevitably to the establishment of an open corridor through to navigable water on the Atlantic Coast about 1960 and since then the attack on the forest front both northward and southward from it has intensified. Interior Honduras, drier and lacking in volcanic soils, perhaps shows less activity but again in northern Guatemala FYDEP, the official colonization agency, has been vigorously promoting the settlement of Kekchi-speaking Maya Indians from the Vera Paz highlands onto farmlands in the southern portion of the Petén, where they are also pushing large scale cattle ranching on both the scattered natural savannas of that area and into the adjacent forests (25). To acquire legal title the *colono* has often been required to clear and plant half of the area to be claimed. Hence, at the beginning of each dry season the attack on the uncleared forest, is zealously renewed, filling the air with smoke from the *roza* fires that give the familiar amber color to the sunlight at this time of year.

After one or two crops of maize, rice or yuca are harvested from the forest clearing, declining soil fertility, invasive weeds and noxious insects combine to force the colono to sell out to a second wave of settlers or speculators who follow behind, consolidating small holdings into larger ones for the exclusive purpose of raising beef cattle. In other cases, where the forest is privately held, the colono is given the right to take two or three crops from a *roza* in exchange for leaving the land in planted pasture at the end of that period, much as alfalfa was established under contract by Italian immigrants to the Argentine pampas in an earlier day. Either way the crops, in effect, pay for the cost of forest clearing. They represent only a transient stage between forest felling and pasture establishment.

At times there seems an almost mindless mania for converting forest to pasture, a kind of *potreroismo* mentality at work here. Yet for the colono who clears the forest and plants in its ashes, enduring countless hardships and difficult living conditions on an isolated and malaria-infested pioneer fringe, it may be the most attractive available alternative. If he does not move on ahead to make new patch clearings in the forest beyond he goes to work for the new owner as a wage

laborer, joining the *chapia* gangs that with machetes fight back the *matorral* or secondary forest that competes with the new grass.

This process of driving back the forest and its replacement by grassland and cropland is hardly anything new; in 1873 **Thomas Belt** (2) wrote:

> After seeing the changes that were wrought during the four and a half years that I was in the country, I have been led to the conclusion that the forest formerly extended much further towards the Pacific, and that it has been beaten back principally by the agency of man. The ancient Indians... cut down patches of the forest and burnt it to plant their corn, as all along the edge of it they do still. The first time (after the corn is gathered) seeds of the forest trees...spring up and regain possession of the ground... After two or three years it is cut down again...and a great variety of weedy looking shrubs found only where the land is cultivated spring up...Should the brushwood ultimately prevail...the Indian or Mestizo comes again after a few years, cuts it down, and replants it with maize. But as most of his old clearings get covered with grass, he is continually encroaching on the edge of the forest, beating it back gradually but surely towards the north-east. As this process has probably been goingon for thousands of years, I believe that the edge of the forest is several miles nearer tne Atlantic than it was originally...
>
> What would be the result if man were withdrawn from the scene I do not know, but I believe that the forest would slowly, but surely regain the ground that it has lost through the centuries... It is far more likely, however, that man will drive back the forest to the very Atlantic than that he will quit the scene. [Everyman's Library edition, London, 1874].

In the wake of the advancing frontier come serious social consequences, including unemployment and a declining rural population. Stock-raising provides few jobs and no seasonal or part-time employment. **Boserup** (3) holds that intensification of agriculture and the adoption of scientific methods of farming are likely to be a consequence of increased densities of rural population, a condition hardly associated with an expanding Central American livestock economy. **Sandner** (34) sees some indication that there may be a slowing of this process of forest clearing and its replacement by grassland, that the land-seeking population may no longer be quite so willing to endure hardships of pioneering in distant, undeveloped areas as it has been in the past. But in most areas time is running out. Within 10-15 years in Costa Rica, perhaps 20 years in Nicaragua and Guatemala, most of the remaining selva will have been destroyed unless drastic measures are taken to preserve it. And much of this clearing will have been on soils at best only marginal for agricultural use or for pasture.

Road-building has enormously facilitated this rapid replacement of forest by cropland and pasture. The Mexican economist Edmundo Flores observes that "roads create space (resources); they give value to previously worthless land by making it accessible and incorporating it within the market area". Wherever a new road is being built colonos are on hand to establish their claims to the new lands being made accessible. When the route has been dictated by engineering rather than ecological principles, the lands it passes through may be ill-adapted for farming. Within a few years, despite large inputs of human labor, such land is often exhausted and left to return to valueless secondary scrub. **Budowski** (5) has observed that more destruction of landscapes has probably been achieved in tropical countries in recent years through the opening of roads than for any other reason. We are finally learning the critical importance of making ecological surveys, before initiating a road-building program but it has been a lesson slowly learned (9).

THE EXTENT OF PASTURE LAND AND NUMBERS OF CATTLE

Statistics on the area in planted pasture in Central America and Panama are incomplete and unreliable. Probably better than two-thirds of the agriculturally productive land is devoted to livestock, and the share is increasing (Fig. 2). In Panama the area in planted pasture increased 43 percent between the 1960 and 1970 agricultural censuses, to 965,000 ha; in Nicaragua it increased by 48 percent, to 1.7 million ha, between 1963 and 1971; in Costa Rica a startling 62 percent to 1.5 million ha, in the 10 years 1963-1973. On the Pacific coastal plains of Guatemala, and on the north coast of Honduras *potreros* have been expanding at comparable rates.

Along with the expanded area in pasture there has also been an increase in cattle numbers and an upgrading of herd quality (42). Except in Costa Rica, however, *criollo* stock generally remains dominant. From 1961-64 to 1972 total numbers of cattle in Central America and Panama increased from 7.4 million to 10.3 million and are projected by FAO to reach 12.9 million by 1980 (17). In Costa Rica the present herd of 1.7 million is double what it was 15 years ago. Guatemala's estimated 1.9 million head of cattle in 1973 represented an increase of one-third in only five years. The Nicaragua cattle population (2.3 million, largest in the area) was up a remarkable 75 percent in a like period (42). Yet only in Nicaragua do cattle outnumber the human population. That country's herd is roughly the size of the cattle population of Denmark. The lowest rates of herd increase have been in Honduras and El Salvador. In Honduras, 80 percent of the cattle are on small farms, few with as many as 50 ha or 50 head, making hold for herd increase difficult. Only in El Salvador has crop production expanded more rapidly than livestock numbers, but even this smallest and most densely settled of Central American republics aspires to become a cattle country (14). Yet its production of basic cereal foods has scarcely kept up with population growth.

Boneless beef export from Central America to the United States, mostly canner-and-cutter grade, began about 1954 and since has steadily increased. In 1974 it was expected to amount to approximately 210 million pounds (100 million kgs) or some 15 percent of total U.S. beef imports (42). Honduras, Nicaragua and Costa Rica are all exporting more than half of their annual beef output despite restrictions or quotas imposed from time to time to insure more adequate supplies for local markets. In some years Costa Rica has exported as much as two-thirds of its total slaughter. As this symposium meets Costa Rica's representatives in Washington are seeking a further 33 percent increase in the country's meat import quota for 1975, to 69 million pounds (31 million kgs).

But Nicaragua is the number one exporter (86 million pounds [40 million kgs] in 1972) and seems likely to remain so. Even El Salvador has joined the parade in the last two years. FAO (17) projects an export availability of 280 million pounds (127 million kgs) of beef carcass weight, by 1980, an increase of 77 percent above 1970 and even higher figures later.

But what does Central America profit from this "protein flight" to the mid-latitudes? While both the area in pasture and the numbers of beef cattle have been expanding vertiginously the per capita consumption of beef in Central America has been declining. Virtually the entire increase in output has been channeled to the profitable export market. Between 1959-1963 and 1972 per capita consumption of beef appears to have climbed only in Nicaragua and Panama, the two countries with much the highest comsumption rates. In Costa Rica it plummeted from 27 to 19 pounds (12 to less than 9 kgs) per capita during this

period despite a doubling of total beef production. Exports absorbed the entire increase in this period. But in Panama, where the surplus goes chiefly to the Canal Zone markets and to sales to U.S. commissaries, the increase in output has gone largely to internal consumption, up from 42 to 52 pounds (19 to 24 kgs) per capita. The comparable increase in Nicaragua in the same period (1959-1963 to 1972) was from 29 to 32 pounds (13 to 14 kgs), (Table 1).

TABLE 1

Central American beef production: consumption and export (in million pounds)

	Total production	Exports	Domestically available	Per capita consumption (lb)	Number of cattle' 73 (millions)
Guatemala					
1959–63 av.	82.3	7.2	75.1	19	
1972	158.9	54.2	104.7	15* *	1.9
Honduras					
1959–63 av.	40.7	––	29.7	16	
1972	90.5	51.0	39.5	14	1.6
El Salvador					
1959–63 av.	40.7	––	43.7	17	
1972	52.3	8.5	43.8	12	1.2
Nicaragua					
1959–63 av.	61.2	20.7	40.5	29	
1972	151.1	86.0	65.1	32	2.3
Costa Rica					
1959–63 av.	53.3	17.5	34.8	27	
1972	108.0	73.7	34.2	19	1.7
Panamá					
1959–63 av.	47.9	1.5	46.4	42	
1972	89.5	9.9	79.6	52	1.3
Belize					
1959–63 av.	.9	.1	1.0	10	
1972	1.2	.6	1.8	14	0.4

* USDA, Foreign Agric. Service. "The beef cattle industries of Central America and Panama". Revised, July 1973.

** Livestock and Meat Report, Agricultural Attaché, US Embassy, Guatemala, Sept. 30, 1974. FAS figure of 19 lbs per capita consumption in Guatemala in 1972 apparently included pork.

There may be one mitigating consideration in this seemingly dreary picture. Figures on supplies of beef available for domestic consumption in Central America are based on dubious estimates of the number and average liveweight of the animals slaughtered in a given year (42). It is suspected that the beef consumption figure often excludes the consumption of viscera (entrails). All of the viscera produced

and passed as wholesome, including that from animals slaughtered for export, is consumed locally-heart, liver, kidney, tripe, tongue, brains, etc. Viscera, being priced relatively low, is an important source of animal protein for many consumers who cannot afford red meat. An increase in the level of exports paradoxically may mean increased supplies of protein for the domestic market-although this increase may not show up in official statistics.

BEHIND THE SHIFT TO GRASS

Why, in the face of malnutrition and underconsumption of protein, is Central America so enthusiastically exporting it, and to one of the best fed nations on earth? Quite clearly because it is profitable to do so–it brings in much needed foreign exchange–but also because stock raising is an activity congenial to the Latin value system. *Ganadero,* like *caballero,* is a term of respect. It carries prestige, and it implies an attractive way of life that is relatively easily entered. With price ceilings imposed on most basic commodities it has not been attractive to the farmer to intensify his efforts to produce rice, maize, beans or yuca. And the market for the traditional export crops such as coffee, bananas and sugar has been notoriously fickle and unreliable. With beef it is another matter, especially since the opening of the U.S. market some 20 years ago. Profits have been good and risks low. Moreover, grass is the easiest of crops to grow. It takes less resources in capital and management to develop pasture than to intensify cropping efforts, and it is simply easier, requiring less work and effort. In some cases the shift to cattle may reflect a desire to avoid labor problems, or perhaps recognition that the tired land has been pushed to the limit and needs a rest. In the drive to diversify exports, government has encouraged an expanding cattle industry, and international agencies have given further support. Especially decisive has been the availability of low-cost credit. In Costa Rica, for example, nearly half of all agricultural credit in recent years has been to the livestock industry (36).

THE DURABILITY OF A GRASSLAND ECONOMY

Can this be a permanent and enduring form of land use? Can beef be produced indefinitely without exhausting the land? Yes, said the late Robert Kleberg of the King Ranch, which in Venezuela and Brazil is spearheading massive, large scale land clearings for just this purpose, provided one takes care of the grass. Yet the United Fruit Company gave up on its efforts at cattle raising at Monkey Ridge near Bluefields, now converted to a modest dairy operation. The Le Tourneau land-opening project at Tourneauvista in the Peruvian Oriente is another case of well-capitalized failure in tropical pasture development. Clearly there are major problems. Corporate giants like Swift and Co., Volkswagen, Daniel Ludwig, even the Japanese, the Germans, and the Arabs, equipped with the most modern land-clearing equipment but often lacking the most rudimentary ecological understanding, are currently converting large blocks of the Amazon rain forest into pasture. In this process a natural biomass that has maintained a large bulk of nutrients in a living cycle is suddenly reduced to a low biomass with a much reduced storage capacity (12, 37). We may learn much from their experiences in the next few years regarding changes that follow from the conversion of natural vegetation to planted pasture and the potential of the humid tropics for supporting a permanent grass economy.

Such development-oriented international organizations as FAO and IBD seem to foresee a kind of mixed farming as the optimal ultimate use for the better soils of the high rainfall Central American forests. For example, a detailed FAO report on Northeastern Nicaragua (16) identifies some 800,000 ha of broadleaf forest as eventually adaptable to cattle raising or mixed farming under a 10-year crop-grass rotation in which four years of rice or maize would be followed by six years in pangola grass pasture. Eventually, it is suggested, the eastern part of Nicaragua should become a major contributor to the country's cereal production, at the same time supporting an additional 1.5 million head of cattle. There is a vision, it seems, of an isthmus converted to cropland and grass from the Pacific to the Atlantic. In Nicaragua a model for this is the 70,000 ha Colonia Rigoberto Cabezas project on the La Gateada-Nueva Guinea road south of the Rama road, recently funded by an $80 million IBD loan. Another is the Siuna mining district, still without land connections with western Nicaragua, where an efficiently run cooperative and the existence of an established market at the mines has opened the way for successful agricultural development in the heart of the rain forest.

THE ADVERSE EFFECTS OF FOREST REMOVAL

The belief that the soil that supports the magnificent tropical forest will yield a succession of rich crops has been proven cruelly illusory. Yet the accepted ecological wisdom, that conversion of tropical forest to grassland for domestic herbivores causes serious deterioration of the soil nutrient level and soil structure has been based on largely inferential evidence (4, 18, 23). We lack data on the magnitude and rate of soil change under differing climates and differing parent materials. No Rothhamsted exists for the tropics with its century-long history of changing soil productivity under differing types of land use. The effect of forest clearing and grass establishment, including annual burning, on mineral cycling, soil microbiology, organic matter content, erosiveness, permeability and runoff are little understood in the tropics. It is clear, however, that much of the nutrient stock locked up in the virgin forest, reduced to ash in the clearing process, is quickly leached beyond the root zone of the shallow rooted grasses and crop plants (30). Unless carefully managed, and usually fertilized, both planted and natural grasses become sparse or woody with overgrowth, trampling, compaction, and declining soil fertility (41). Hand weeding is costly, and seasonal burning is not always feasible, especially in the wetter areas towards the Atlantic coast. In some situations the sharp reduction in transpiration following forest removal produced such a rise in the water table that agriculture becomes impossible. Commercial fertilizers, scarce and expensive, must be applied with care to minimize wasteage by leaching and chemical recombination in the acid soils, for physical processes are much speeded up here as compared to temperate lands. Here too, plant and animal diseases and parasites find their optimal habitat. Much depends on both the length and severity of the dry season and on the character of the underlying parent material. Soils developed on limestone, on volcanic rocks, or on recent alluvium clearly have a much greater inherent fertility than those on older, weathered upland surfaces. It is on the last that most of the remaining forests of Central America are found.

One way to avoid the wastefulness of present systems of tropical land use, wasteful of the original forest and of human labor, would be by replacement of dependence on cereals, roots and grasses by a new diversified tree-crop or

multi-storied agriculture (23, 41). By simulating the forest environment and its high biomass productivity (40)—production of carbohydrates and protein of both plant and animal origin might be maximized. Tree crops, including browse for cattle, undoubtedly offer much promise, but the plantation system under which most tree crops have been most effectively grown in the past is politically and socially unstable and probably unacceptable. In Costa Rica, at least, dairy farmers have worked out an interesting system of planting fast-growing alder trees *(Alnus jorullensis),* here called "jaul", in planted pastures where they provide shade for cattle as well as saw-timber, while by fixing nitrogen in the soil they are supposed to have a beneficial effect on the pasture grass (22).

In drier parts of the tropical lowlands, with a *verano* of five months or more duration, the soil is probably better adapted to grassland agriculture, despite the stress caused by seasonal feed shortages, than in wetter areas. Thus, in Guanacaste province, Costa Rica, **Daubenmire** (10) found little change in the fertility and physical structure of the soil after twenty-two years in planted pasture. In particular, he found no suggestion of downward movement of clay or other irreversible changes in the profile of the study site near Cañas, as some authorities have suggested, and he doubts that other Guanacaste soils have undergone such deterioration. Erosion between the conspicuously pedestaled bunches of jaragua grass appeared to be the most significant environmental change under pasture in this particular case. Similar paired tests in other life zones are badly needed.

Soil erosion is generally much less under a good stand of grass than on tilled slopes and may not be greatly in excess of that under fully developed tropical forest (1). Still, there is a wide variation in the coefficients of infiltration and runoff. In drier areas tall grass gives the illusion of complete soil cover, an impression that does not survive close inspection. The hydraulic regime is quite likely to be altered drastically, especially on steep slopes, in the year or two following clearing, and this may induce flow irregularities and reservoir sedimentation downstream that can have disastrous effects on hydroelectric power generation (11). But these considerations do not rule out grass. They only remind us of the necessity for caution.

INTENSIVE TROPICAL PASTURE MANAGEMENT

The alternative to the continued expansion of pasture at the expense of the remaining tropical forest is better use of existing grassland. **Sternberg** (38) observes that livestock production in developing countries is currently among the world's most inefficient industries. One recent report suggests that the present beef cattle population of tropical grassland areas of Latin America could probably be increased four or five times and total marketable meat production up to ten fold through application of available knowledge to existing pasture and animal resources.

On theoretical grounds the greatest grassland potential in the world ought to lie in the humid tropics where year-round warmth, adequate rainfall and deep porous soils prevail (19, 39, 43). This view finds forceful expression especially in reports of long-term investigations carried out in places like tropical Queensland, Florida and Puerto Rico. It assumes, however, the input of capital and management skills of a fairly high order, as well as economic and political stability. Intensive grassland management practices that have proven effective in a wet-and-dry season tropical environment similar to that of Central America are convincingly detailed in an important recent publication, *Bulletin 233,* of the Puerto Rican

Agricultural Experiment Station (43) and in the journal of the Tropical Grassland Society of Australia, *Tropical Grasslands.* From such well-subsidized centers of tropical grassland studies the general tone is one of confidence and optimism.

But high-yield tropical grassland farming in such areas is closely tied to heavy fertilization in a world and at a time when fertilizers are becoming expensive and in critically short supply, although more from limitation in plant capacity than from any permanent change in supply-demand relationships. Appropriate levels of fertilization and frequency of its application on different soil types are a major concern of this experiment station literature, for most tropical soils are inherently low in nutrients and there is heavy nutrient loss through forage take-off, leaching and fixation. Nitrogen is the key. With adequate application, both the bulk yield and the protein content of grass increases sharply, especially where organic matter content of the soils is low. It is especially effective in keeping nitrogen content up during the dry season.

There has been some modest success in developing nitrogen-fixing tropical legumes appropriate for grassland farming in Australia but in general legumes are not able to compete with the vigorous tropical grasses, especially on the acid soils of high rainfall areas. Apparently, however, the recent discovery of nitrogen-fixing strains of *Paspalum notatum* (Bahía) and Transvaal Pangola *(Digitaria decumbens),* the latter a hybrid developed in Florida, holds out a substantial hope for the future. When the soil is inoculated with appropriate bacteria, these grasses are said to produce up to 80 kg/ha a year of nitrogen, not as root nodules but within the cell structure (Hugh Popenoe, pers. comm.).

The natural cycling of nutrients through grazing cattle is a part of the appeal of a mixed farming system with both crops and livestock in the mid-latitude tradition. About 80% of the nitrogen, phosphorus and potassium consumed by cattle is returned to the soil in the form of manure. But grazing animals are not very effective in maintaining pasture fertility, mostly because of poor distribution of this excreta. Even under the best of conditions in Puerto Rico about half of it is lost through volatilization and leaching (43). To be fully effective, urine and feces should be mixed and distributed uniformly in the field, something that is uneconomic in high labor-cost areas but which may be feasible in Central America.

There are other approaches to an intensified grassland farming. Especially effective is the investment in fencing that permits carefully-timed rotational grazing, using individual potreros sufficiently small that the forage is consumed down to the indicated height in not more than one week in any individual plot. This practice, well appreciated by dairymen, as on the Meseta of Costa Rica has not yet been widely adapted by cattlemen. Again, the feeding of supplements during the dry season–little employed to date with Central American beef cattle–awaits improvements in systems of tropical hay curing and in the making of ensilage. Or, by feeding urea–a low cost form of synthetic nitrogen–it is possible to vastly increase the cow's capacity to digest cellulose, whether from coarse tropical grasses, sawdust or corn stalks, and so to concentrate its protein. To do this molasses, usually cheap and abundant in the tropics is fed to help "prime the pump", to initiate the fermentation process in the cow's rumen.

Such approaches to intensive pasture management, including the continued search for improved higher yielding grasses, offer attractive and probably economically viable alternatives to the continued destruction of forest lands and their conversion into grass. Or, if protein availability becomes the problem, we can even argue the case for the greater efficiency of poultry or hogs as compared to a long-cycle livestock population in which only one fourth of the herd can be harvested in a given year.

THE AFRICAN ORIGIN OF ARTIFICIAL PASTURE GRASSES

It is not well appreciated that these new pasture lands are overwhelmingly comprised of grasses of African origin that have only recently been introduced into Central America, usually through Brazil or the United States (28). Several of them have become naturalized and have spread widely as volunteers, so that we can almost speak of an "Africanization" of the Central American landscape (37). These African grasses are almost invariably more palatable to livestock than the native American species, and more productive. It is impossible to imagine the present level of development of stock raising in Central America without them.

Longest established of the African grasses is Guinea grass *(Panicum maximum)* a tall-growing clump-former that may be propagated either by seeds or by cuttings. In Central America it may be known as *privilegio* or *zacatón*. Introduced to the British West Indies in 1741, originally as a promising source of bird seed, Guinea grass apparently reached Central America sometime about the middle of the 19th century. In 1870 "great Guinea grass potreros full of fat cattle" were described in Guatemala as one of the principal arms of wealth of that republic (15). The seed was introduced into Costa Rica in 1885 (29).

Pará grass *(Brachiara mutica)*, a lower growing species spreading chiefly by runners, is to the poorly drained bottom lands of the *tierra caliente* what Guinea grass is to better drained soils. It has been so long established in Brazil that it has erroneously been listed as a native. Its introduction into Colombia, along with Guinea grass, in the 1820's has been termed the most important economic event in that country between 1820 and the establishment of coffee as the country's major commercial crop near the end of the century (26). Pará appears to have arrived in Central America a few years later than Guinea grass. We only know that it was in Guatemala prior to 1872.

Melinis minutiflora or molasses grass *(gordura, melado)*, so named for its distinctive sweet odor and the gummy exudations that make its hairy leaves sticky, is so widespread in the coffee areas of Brazil that is has often been presumed to be a natural of that country. But it is also originally from Africa. It is a volunteer on worn-out cafetales, road cuts, railway embankments and even on poorer soils under native pasture grass. It is first mentioned in Costa Rica in 1908. Twenty years later it was described as completely naturalized there. It has proved an excellent soil holder on steeper slopes of the *tierra templada*, but cattle are sometimes slow to accept it. It does not withstand trampling, nor does it come back well after fire.

Jaragua *(Hyparrhenia rufa)*, a member of one of the two most common genera of tropical African grasses, is the most important and widespread introduced grass in the New World. It is dispersed by seed with uncommon ease and is strongly invigorated by annual burning. Although it was known earlier in Brazil, Colombia seems to have served as the staging base from which the red-tipped jaragua, like molasses grass, spread to the rest of tropical America. By 1920 it was established in Guatemala, El Salvador and Costa Rica (30). Especially where the dry season lasts five months or more, it has had a strong competitive advantage. It reaches its maximum development on the Pacific side of Central America. It was termed the "salvation of Guanacaste" following the drought of the 1920's. Like most tropical grasses it must be grazed rather closely during the rainy period to avoid becoming rank and fibrous.

In contrast to the other African immigrants kikuyu grass *(Pennisetum clandestinum)* belongs chiefly to the cool uplands. In the last twenty years it has spread explosively throughout the higher elevations of middle and South America

wherever there is adequate moisture. It shows vigorous vegetative development of runners and stolons but its reproductive organs tend to be reduced and stunted. This concentration on vegetative matter may enhance its value as pasture. It first reached the New World about fifty years ago, probably being distributed through experiment station efforts. It arrived in Guatemala in 1923 and in Costa Rica five years later. Escaped, it was at first considered an extraordinarily noxious weed, but today it is recognized as a valued pasture resource at elevations above 1,400 meters (4,500 feet). In a period of about forty years since its introduction onto the *sabana* of Bogotá it has almost completely overrun every open field and roadside, choking out all competition. Similarly, it has invaded the Quito basin and parts of the valley of Mexico. It mantels the terraces of the famous ruins of Machu-Pichu in Perú. Following the 1963-65 eruptions of Volcan Irazú in Costa Rica, when all other grasses were killed off, kikuyu came back early and strongly, apparently invigorated by the ash. Dairymen who once scorned it now describe kikuyu as their strongest, most resistent and resilient pasture grass, supporting two head of cattle per hectare throughout the year.

A more recent African invader is pangola grass *(Digitaria decumbens),* introduced into a Florida experiment station in 1935 from where it was taken to Central and South America. Like kikuyu it is propagated exclusively by stolons or stem cuttings. Currently it enjoys great popularity in tropical America, although in some areas it is subject to a destructive virus disease. It responds especially well to fertilization. Pangola was introduced into Costa Rica in 1946, probably moving from here into other Central American countries. It is probably the most common artificial pasture in the San Carlos area and in the Valle de El General of Costa Rica today, as it is on the Pacific coastal plain of Guatemala. The current enthusiasm among stockmen is African star grass *(Cynodon niemfuensis?),* possibly a Puerto Rican cultivar, of the same genera as the pan-tropic Bermuda grass. The seed are not viable. It spreads rapidly by extremely vigorous surface runners and quickly covers the ground. This "kikuyu of the lowlands" is a preferred pasture grass especially in the more humid regions, being said to out-produce all competitors.

Among other grasses of African origin that are well established in Central America are signal grass *(Brachiaria brizantha),* Bermuda *(Cynodon dactylon),* Johnson grass *(Sorghum halepensis),* Rhodes grass *(Chloris gayana),* elephant *(Pennisetum purpureum)* and Natal grass *(Tricholaena rosea).* Although some of these are aggressive colonizers, none has as yet the importance of the other species reviewed.

TOWARDS A BALANCED DEVELOPMENT

There is little prospect of stemming the process of conversion of forest to pasture so long as government attitudes support the continuing expansion of stock raising. As pasture area expands the annual crops that supply most of the local food requirements are displaced onto increasingly marginal, inaccessible lands while the better areas closer to population centers go under grass, contrary to the classical theory of location of Johann von Thünen. In terms of preservation perhaps the best that can be hoped for now may be the setting aside of some substantial natural reserves of the rapidly disappearing lowland and montane forest habitats to preserve for posterity at least some of their enormous floral and faunal diversity. A pre-requisite of a successful system of reserves, as **Archie Carr** (6) has observed, is a land ethic that understands and supports the rationale for it. An economically

advanced society can think of welfare in terms of abstract values. To people in much of Central America today, however, such values and that sort of welfare seem overshadowed by problems of nutrition, public health and political change. Still, he says, the time may be approaching when wilderness will also be recognized as wealth. Then, that village with the incomparable quetzal, or a nightingale thrush, in a cloud forest above it, will be blessed among villages. And if carefully planned trails and viewing balconies are constructed, it may find itself with a demonstrably economic asset.

Much emphasis has been placed on the virtues of diversity with relation to tropical environments. Economic diversity should be as much of a consideration as ecologic diversity. A grassland monoculture, carried to extreme, could put the Central American economies at the mercy of the world market for meat in much the same way that bananas and coffee did earlier. A quarantine on Central American beef in the United States as a result of an unanticipated epidemic–or the cutting of quotas, for whatever reason, could have disastrous consequences. Yet mixed farming, however idealized, has not always given the results expected of it either. Settlers on the Coto Brus frontier in Costa Rica, after years of effort, have found themselves once more reduced to a coffee monoculture. No other crops can be produced and marketed competitively. An initial optimism has been reduced to a lean skepticism more closely defined as the need to survive than a will to succeed (8).

Clearly, development must be within the limits of the environment. Can energy-intensive industrial farming realistically be expected to survive in the face of growing scarcities of fertilizers and hydrocarbon fuels? There is no more important question. As a first step we surely need to get off the reckless energy binge we have been enjoying and think about allocating resources to more nearly maximize long-term benefits which should probably be defined in nitrogen-fertilizer units. A fossil-fuel subsidized monoculture, whether it produces beef or commercial export crops, must in the end be replaced by a self-sustaining agroecosystem (21, 23). In this the aboriginal inhabitants of Central America long ago showed the way. Perhaps it was their great blessing, as **Skutch** (35) has suggested, that they had no livestock and were thus without motivation to create pasture. Still, the cow, itself a product of the tropics, is a magnificent converter of cellulose into protein, the best there is. With perseverance a durable grassland economy based on sound ecological principles is probably within reach. More than enough of the forest resource has been cleared already for this purpose. It is time now to pause in this mad assault on nature, time to think more in terms of saving what is left. We are rapidly running out of both time and the forest.

RESUMEN

La expansión de pastos artificiales o cultivados, a expensas del bosque natural y de tierras agrícolas en Centro América en los últimos años, ha traído consigo importantes cambios, tanto en su paisaje como en su economía. La agricultura pionera a las orillas del bosque generalmente no es más que una etapa transitoria entre la tala del bosque y el establecimiento de potreros permanentes. Mientras que el área ocupada por pastizales y el número total de cabezas de ganado se han casi duplicado en varios países Centroamericanos en los últimos 15 años, el consumo per-cápita de carne ha bajado. Prácticamente la totalidad del aumento en la producción de carne se ha destinado a los mercados de exportación. El consumo

per-cápita durante los 5 años entre 1959-1963, aumentó solamente en Nicaragua y Panamá, que son los dos países con la tasa más alta. En Costa Rica bajó brúscamente de 27 a 19 libras per-cápita en ese mismo período, a pesar de que se dobló la producción total de carne de res.

Las consequencias ecológicas de la transformación de bosques en pastizales son poco comprendidas. Para mantener la productividad de estas tierras bajo las condiciones propias de los climas tropicales, serán necesarias prácticas de manejo intensivo, incluyendo la aplicación de fertilizantes, que son escasos y de alto costo, y sistemas de rotación de pastoreo cuidadosamente manejados.

La "revolución de pastos" que están experimentando Centro América y Panamá, está basada casi exclusivamente en especies de pastos de origen africano que en su mayoría han sido importados a Centro América durante el presente siglo. De estos, los más importantes son jaragua, guinea, pangola y kikuyu. Todos han demostrado ser colonizadores agresivos, propagándose ampliamente fuera de las áreas donde fueron establecidos inicialmente. Indudablemente han mejorado el forraje para la ganadería y han facilitado la rápida expansión de la producción de carne para la exportación. No obstante, la gama de alternativas para el futuro desarrollo se ha reducido como resultado de lo que podría ser un deterioro permanente de la fertilidad del suelo, consecuencia de la destrucción del bosque y su sustitución por pastos de raíces poco profundas.

LITERATURE CITED

1. **Alberts, H. W., & O. García-Molinari**
1943. *Pastures of Puerto Rico and their relation to soil conservation.* U.S.D.A. Misc. Publ. No. 613.

2. **Belt, T.**
1874. *Naturalist in Nicaragua.* Everyman's Library, London.

3. **Boserup, Esther.**
1965. *The conditions of agricultural growth: the economics of agrarian change under population pressure.* Aldine, Chicago.

4. **Budowski, G.**
1956. Tropical savannas: a sequence of forest felling and repeated burnings. *Turrialba,* 6: 23-33.

5. **Budowski, G.**
1970. *The opening of new areas and landscape planning in tropical countries* (with special reference to Latin America). XII Congress of the International Federation of Landscape Architects. Lisbon, Sept., 1970.

6. **Carr, A. F.**
1969. Thoughts on wilderness preservation and a Central American land ethic. *Audubon,* 71: 52-55.

7. **Centro Internacional de Agricultura (CIAT)**
1969. *Annual Report.* Cali, Colombia.

8. **Cole, D. G.**
1968. The myth of fertility dooms development plans. *Natl. Observer,* Apr. 22, p. 10.

9. **Dasman, R. F., J. P. Milton, & P. H. Freeman**
1973. *Ecological principals for economic development.* Wiley, London and New York.

10. **Daubenmire, R.**
1972. Some ecologic consequences of converting forest to savanna in northwestern Costa Rica. *Trop. Ecol.*, 13: 31-51.

11. **Daugherty, H. F.**
1973. *Conservación ambiental en El Salvador: recomendación para un programa de acción nacional.* The Conservation Foundation, Washington, D. C.

12. **Denevan, W. M.**
1973. Development and the imminent demise of the Amazon rain forest, p. 80-85. *In* David Hill (ed.) *Latin American Development Issues.* Proceedings of the Conference of Latin Americanist Geographers, 1971, vol. 3. CLAG Publications, East Lansing, Mich.

13. **Dickinson, J., III.**
1973. Protein flight from Latin America: some social and ecological considerations, p. 127-132. *In* David Hill (ed.), *Latin American Development Issues.* Proceedings of the Conference of Latin Americanist Geographers, 1971, vol. 3. CLAG Publications, East Lansing, Mich.

14. **1971.** El Salvador puede y debe ser un país ganadero. *Agric. El Salvador,* enero, 1971.

15. **Esponda, J. M.**
1888. *Manual Práctico del nuevo ganadero mexicano.* Mexico.

16. **FAO**
1969. *Survey of agricultural and forest resources–Nicaragua. Final Report.* vol. 1: General. vol. 2: El desarrollo agrícola. Estudio de los recursos agrícolas y forestales del noreste–Nicaragua. Informe final. Rome.

17. **FAO**
1971. *Agricultural commodity projections, 1970-1980.* Rome.

18. **Farnsworth, E. G., & F. B. Golley (eds.)**
1974. *Fragile ecosystems: evaluation of research and applications in the neotropics.* The Institute of Ecology. Springer-Verlag, New York.

19. **Garst, J.**
1963. *No need for hunger.* Random House, New York.

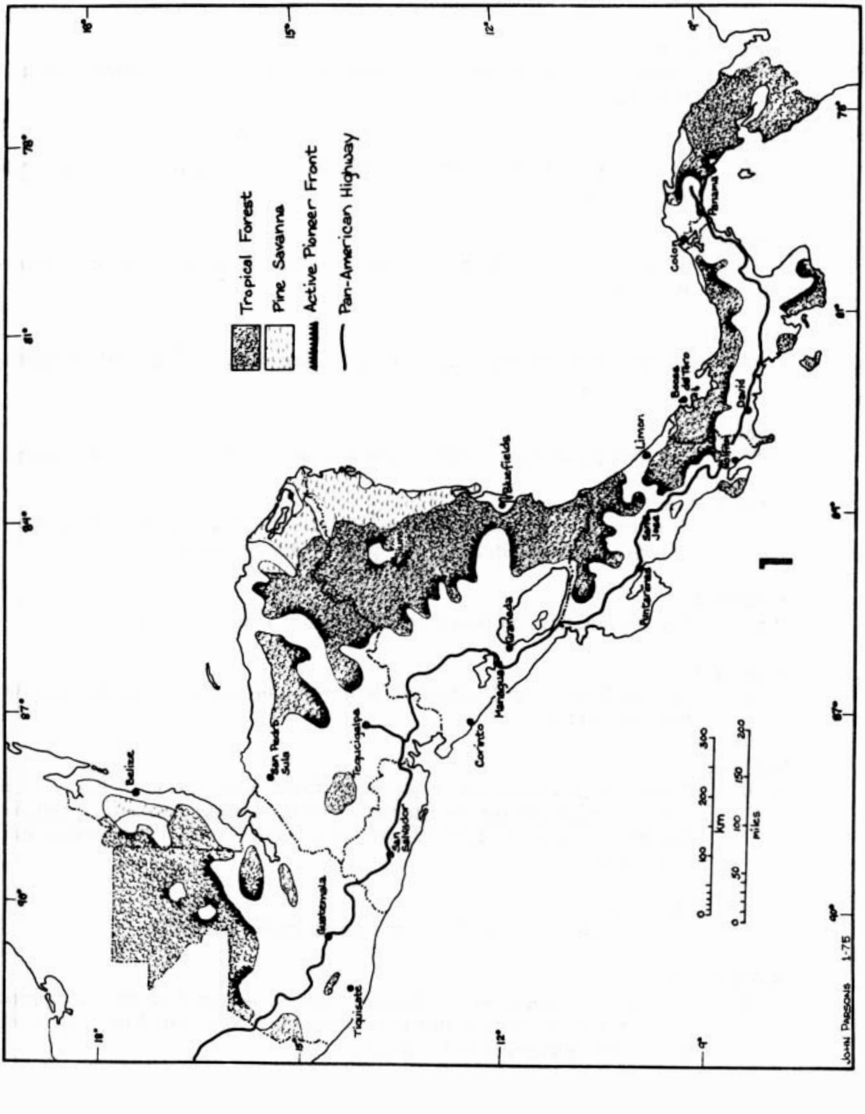
20. **Gordon, B. L.**
1967. *Anthropogeography and rain forest ecology of Bocas del Toro Province, Panama.* Department of Geography, University of California, Berkely. (processed)

21. **Harper, J. L.**
1974. Agricultural ecosystems (Editorial). *Agro-Ecosystems* 1: 1-6.

22. **Holdridge, L. R.**
1955. Costa Rica (Agriculture and forestry, cooperation or co–existence). *Int. J. Agr. Aff.*, 2: 94–999.

23. **Janzen, D. H.**
1973. Tropical agroecosystems. *Science,* 182: 1212–1219

Fig. 1. Forest retreat in Central America (Sandner, 34).


Tropical Forest
Pine Savanna
Active Pioneer Front
Pan-American Highway
Belize
San Pedro Sula
Tegucigalpa
San Salvador
Guatemala
Tiquisate
Corinto
Managua
Granada
Bluefields
Limon
Puntarenas
San Jose
Bocas del Toro
David
Colon
Panama
km
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JOHN PARSONS 1-75

24. **1971. Limitations to dairy production in the tropics. Proceedings of the Conference held at Wollongar, NSW, May 10-14, 1971.** *Trop. Grasslands,* Brisbaine, 5 (3).

25. **Minkel, C. W.**
1968. Colonization in the Sebol region in north central Guatemala. *Pacific Viewpoint,* 1968: 69-73.

26. **Ospina Vasquez, L.**
1955. *Industria y protección en Colombia, 1810-1930.* Editorial Santafe, Medellín.

27. **Parsons, J. J.**
1965. Cotton and cattle in the Pacific lowlands of Central America. *J. Interamer. Stud.,* 7: 149-159.

28. **Parsons, J. J.**
1972. Spread of African pasture grasses to the American tropics. *J. Range Managem.* 25: 12-17.

29. **Pittier, H.**
1957. *Ensayo sobre plantas usuales de Costa Rica.* 2da. ed. Editorial Universitaria, San José, Costa Rica.

30. **Sáenz, A.**
1955. *Los forrages de Costa Rica.* Universidad de Costa Rica, Fac. de Agronomía.

31. **Sánchez, P. A. (ed.)**
1973. *A review of soils research in tropical Latin America.* North Carolina Agric. Exp. Sta. Techn. Bull. 219. (Also published in Spanish).

32. **Sandner, G.**
1961. Agrakolonisation in Costa Rica. *Schr. Geogr. Inst. Univ. Kiel,* 19.

33. **Sandner, G.**
1964. Die Eschliessung der Karibischen Waldregion im Südlichen Zentral Amerika. *Erde,* 95: 111-131.

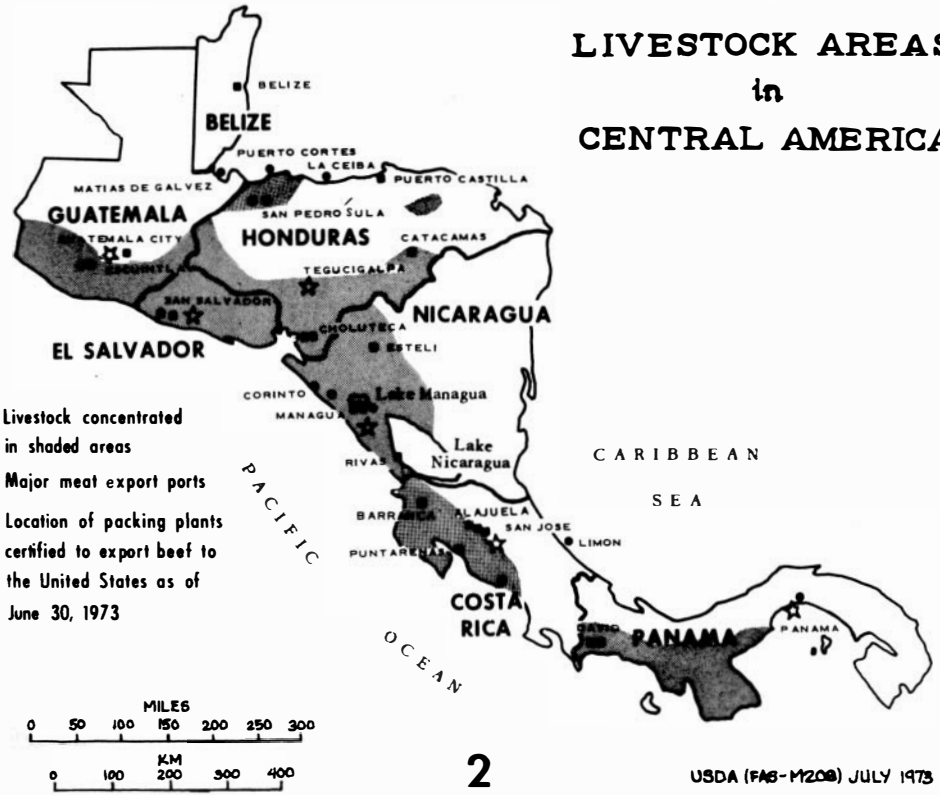
34. **Sandner, G.**
1970. Population pressures on resources in Costa Rica. *In* W. Zelinsky *et al.* (eds.). *Symposium on the geography of population pressure on physical and social resources.* International Geographic Union, Pennsylvania State University,

35. **Skutch, A. F.**
1971. *Naturalist in Costa Rica.* Univ. of Florida Press, Gainesville

36. **Spelmann, H. O.**
1972. *La expansión ganadera en Costa Rica, problemas de desarrollo agropecuario.* Informe semestral, Instituto Geográfico Nacional, San José, Costa Rica, julio a diciembre 1972: 33-57.

37. **Sternberg, H. O.**
1968. Man and environmental change in South America. pp. 413-445. *In* F. J. Fittkau, *et al.* (eds.), *Biogeography and ecology in South America.* W. Junk N. V., The Hague.

Fig. 2. Livestock areas in Central America.


LIVESTOCK AREAS
in
CENTRAL AMERICA
BELIZE
BELIZE
PUERTO CORTES
LA CEIBA
PUERTO CASTILLA
MATIAS DE GALVEZ
GUATEMALA
GUATEMALA CITY
SAN PEDRO SULA
HONDURAS
CATACAMAS
TEGUCIGALPA
SAN SALVADOR
NICARAGUA
CHOLUTECA
ESTELI
EL SALVADOR
CORINTO
MANAGUA
Lake Managua
Lake Nicaragua
RIVAS
CARIBBEAN
SEA
PACIFIC
OCEAN
BARRANCA
ALAJUELA
SAN JOSE
LIMON
PUNTARENAS
COSTA RICA
PANAMA
PANAMA
Livestock concentrated in shaded areas
• Major meat export ports
▪ Location of packing plants certified to export beef to the United States as of June 30, 1973
MILES
0 50 100 150 200 250 300
KM
0 100 200 300 400
2
USDA (FAS-M208) JULY 1973

38. **Sternberg, H. O.**
1973. Development and conservation. *Erdkunde*, 27: 253-265.

39. **Tietzel, J. K.**
1974. Beef cattle in the wet tropics. I-IV. *Queensland Agric. J.*, 100: 98.

40. **Tosi, J. A.**
1974. *Los recursos forestales de Costa Rica.* 1st. National Congress on Renewable National Resources, San José, Costa Rica (in press).

41. **Tosi, J. A., & R. Voertmann**
1964. Some environmental factors in the economic development of the tropics. *Econ. Geogr.* 41: 189-205.

42. **U.S.D.A. Off. For. Agric.**
1973. *The beef cattle industries of Central America and Panama.* Washington, D. C., revised.

43. **Vicente-Chandler, J.,**
1974. *Intensive grassland management in the humid tropics of Puerto Rico.* Agric. Exp. Sta., Río Piedras, P. R., Bull. 233.