PASTURES AFTER HUMID TROPICS FOREST CLEARING IN THE AMAZON

J.M. Toledo* and E.A. Serrao**

ABSTRACT

Beef cattle ranching and dual-purpose mixed farming systems based on pastures after forest clearing have been major developments in the Amazon Basin, especially in Brazil, Colombia and Peru. The bio-economic success of this development is in question. In fact, a high proportion of the established pastures in the region during the past two decades are in advanced stages of degradation, resulting in low productivity farming systems as well as in ecosystem degradation.

In general, after forest clearing and burning of the original biomass, there was an initial high pulse of fertility that warrants a successful establishment of traditional commercially available pasture grasses. Initially, these pastures are able to produce relatively high levels of pasture biomass that are able to carry more than two animals per hectare; however, in relatively short time, these pastures rapidly degrade into derived "native" grasslands of low productivity or are

---

* Centro Internacional de Agricultura Tropical, Apartado Aéreo 6713, Cali, Colombia.

** Centro de Pesquisa Agropecuária do Trópico Umido, CPATU-EMBRAPA, Rua Eneas Pinheiro s/n, Caixa Postal 48, 66.000 Belém, Pará, Brasil

invaded by weeds and secondary forest. The main causes for this degradation are the lack of adapted pasture (grass-legume) germplasm, to the edaphic limitations of the predominant Oxisols and Ultisols in the region, biotic factors such as spittlebug damage to pasture grasses, the non use of legume, and the difficulties in managing a highly dynamic degradation process.

This paper discusses the main causes of pasture degradation, the most promising technological options for reclamation of degraded pastures, as well as future research needs and strategies to obtain highly productive sustainable pastures, ecologically and economically justifiable in this ecosystem.

INTRODUCTION

Before talking about pastures in the Amazon, the controversy between ecologists and developers should be recognized. Pastures are being acused by ecologists as the main cause of degradation of the rainforest in this region. On the other hand, pastures and cattle production are considered by developers as the production system that makes the better use of land, capital and scarse labor availability in the origin. In the past large amounts of subsidies and incentives have been given to cattle ranching in the region. In fact even the small land holders, after the option of shifting cultivation is no longer possible, they turn the land into pastures (Kudzu, Brachiaria spp.) as the best way to tame the land, protect it from weed invasion and to use the area for cattle production.

The two extreme positions, are wrong. On one hand, with the commercially available technology, pastures in the region are in fact a threat to the rainforest ecosystem. This is, mostly because these have low sustainability. Rapid degradation is a general problem with the used species under the predominantly poor acid soils and high biotic pressures in the region. On the other hand, the forests pastures have a tremendous potential of improving soil condition and recycling nutrients with appropriate technology based on adapted germplasm developed for the reclamation of already degraded lands. The real situation is that cattle industry based on pastures, despite of the lack of technology, is growing in the Amazon.

It is estimated that more than six million hectares of rainforest of the Amazon at present have been turned into pastures. This is about one percent of the total rainforest area of the Amazon, which includes one third of Brazil and fourth of Colombia and one half of Peru. Most of these six hundred million hectares of land are covered by predominantly acid poor soils as Oxisols and Ultisols (Cochrane 1985).

This paper discusses the main causes of pasture degradation, the most promising technological options for the reclamation of degraded lands, as well as the research needs to develop highly productive as well as sustainable pastures.

Table 1. Population growth of several cities of the Amazon.

Country/City	Year 1920	1940	1960	1980
	x 1000			
BRAZIL				
Belem	100	210	400	920
Manaus	60	100	170	630
COLOMBIA				
Florencia	-	8	56	120
PERU				
Iquitos	20	32	160	350
Pucallpa	-	1	22	195

Source: OEA. America en cifras (several years).
IBGE: Anuncivo Estatistico do Brasil (several years).

DEVELOPMENT OF THE REGION

The Amazon is not virgin anymore. This region has been under very active colonization mostly during the last century. Table 1 shows the population growth of several cities of the Amazon. The development of new cities during the last sixty years (Florencia in Colombia and Pucallpa of Peru) should be noted, as well as the exponential growth of all cities in the region. This is a clear indication of a present and future rapid rate of development in the region.

In fact countries like Brazil in the 1960's provided developers with subsidies and incentives to clear the land for agricultural purposes. Highways were built to promote settling in the region. The intention was to occupy the region and to alleviate socioeconomic problems in other regions of the country. As a result, large land clearing for

pastures have occurred in the southwest and southeast of the Amazon basin in Brazil. Where extensive areas have been planted to traditional grasses such as Hyparrhenia rufa, Panicum maximum, Brachiaria decumbens, on this basis beef extensive ranching production systems were developed.

On the other hand, non subsidize spontaneous colonization occurred in the Amazon of Colombia, Ecuador and Peru, due to socioeconomic pressures from other poor regions of the countries. The result was the development of shifting cultivation settlements followed by the development of cattle production systems. These mixed farming systems are characterized by being mostly small in area and resulted in semi-intensive dual purpose (beef-milk) farming systems as in Caqueta (A. Ramírez y C. Serè, 1987) or mixed (Crop Pastures Fallow) farming systems as in the Peruvian Amazon (Riesco et al, 1982).

THE DEGRADATION

From the 8 million hectares of pastures established in the region, it is estimated that about 75 percent are in a clear process of degradation. This pasture degradation process (rapid decline of land productivity plus continuous growth of the cattle herds), effectively increase the pressure for more land clearing of the rainforest.

a. The process of pasture degradation

After the clearing and burning of the original forest biomass a boost of soil fertility occurred. It has been documented that most of the

nutrients in the rainforest system, are in the biomass and in the litter, while only a reduced amount of nutrients are present in the soil. Consequently, after the placement of all nutrients of the biomass in the soil in the form of ashes and organic matter, the result is an increase of the soil pH and nutrient availability status of the soil (Nye, 1961; Odun and Pigeon, 1970; Golley et al., 1976; and Herrera et al., 1978).

Under these higher but ephimeral soil fertility conditions, pasture establishment is mostly successful. Highly soil fertility demanding species such as Panicum maximum, Hyparrhenia rufa, Axonopus scoparius and Axonopus micay, aggressively dominate the area immediately after the burning of the forest. However, under grazing their productivity rapidly (3-5 years) degrade loosing covering capacity and allowing weed invasion. The lost of soluble nutrients rapidly increases in the soil, mostly due to runoff and leaching after the exposure of the soil. Simultaneously chemical phosphorus fixation occurs (Oxisols and Ultisols) (Toledo y Ara, 1977; Serrao et al., 1978; Alvim, 1978; Toledo and Serrao, 1982; Seubert et al., 1977; Ferreira da Silva, 1978). In addition, after loosing the pastures cover, a rapid superficial compaction of the soil occur as a result of trampling by the cattle. In this way, the original carrying capacity of the pastures, normally above two animals per hectare, decline to less than .5 animals per hectare. In some cases, the area is fully covered by weeds and the slow process of regeneration of the forests is initiated. This process of regeneration of forests is rather slow, mostly because poorer nutrients status (low pH, P, and CEC), physical condition (compaction

and low infiltration rates) of the soil and seed reserves of the original biomass are being drastically modified. This contrast with what is observed in shifting cultivation systems where the area is only utilized only for 1 or 2 years and the secondary forest rapidly regenerates (Bandy y Benites, 1987; Ferreira da Silva, 1978; Bushbaker, 1984).

On the other hand, following the degradation of the planted pasture species, the farmers in the most humid areas of the Amazon (northwest of Brazil, most of Peru, Colombia and Ecuador) and in more intensively managed cattle production systems, are able to control weeding invasion. In this way, the introduced species are replaced by a grassland canopy composed of Paspalum conjugatum, P. notatum, Axonopus compressus and few legumes such as Calopogonium mucunoides, Desmodium incanum, D. macendens and D. triflorum. This native community is called "Torourco" in Peru and "Grama o Criaderos" in Colombia. This community is a fairly stable disclimax of the ecosystems induced by grazing and weed control. Its carrying capacity ranges from 0.5 to 0.8 AU/ha. This grassland community could be further degraded into unpalatable species such Imperata brasiliensis in the dryer regions of the Amazon where fire is commonly utilized; or Homolepis aturensis in the wetter regions under overgrazing conditions (Toledo, 1984).

b. Why pastures degrade

The main causes of pastures degradation in the Amazon are:

Inappropriate germplasm:

As mentioned above, the highly soil fertility demanding species used, degrade and reduce their capacity to compete with weeds under the

changing soil fertility status. In the same way species such as Brachiaria decumbens, which are highly adapted to the poor acid soils, are negatively affected and degraded in the region mostly due to the attack of the pests 'spittlebug' (Zulia colombiana, Deois incompleta, Mahanarva spp.) (Calderón, 1983). It is clearly that the lack of adaptation of the species to soil conditions and the lack of resistence to biotic pressures of the ecosystem, are the most critical factors responsible of the degradation of pastures in the ecosystem. Adapted new germplasm, without being the panacea, constitutes the basis for a sustainable pasture system in the region.

Failure to include legumes:

In the past and present, most tropical pastures established in the region are pure grass stands. However in few cases Pueraria phaseoloides (tropical Kudzú) and common Centrosema pubescens have been used associated with grasses. While tropical Kudzú tended to dominate the pastures, mostly due to its low palatability and aggressive climbing stoloniferous nature, common Centrosema pubescens, failed to persist under grazing, and degraded together with the associating grasses. These previous experiences, together with the failure of legume cultivars selected elsewhere, massively introduced in the area in the 60's, make farmers, extensionists, and even researchers believe that grass/legume pastures are difficult to impossible to be managed for persistence and stability. This further encourage farmers to predominantly establish pastures in the region with no legume association.

The N fixing role of the legume in the pasture systems are in this way missing. Thus, even grass species well adapted to the acidity and low fertility status of the soils as Brachiaria decumbens and Brachiaria humidicola, after few months, show clear indications of N deficiency, reducing its productivity and its capacity to compete with weeds. In some cases chemical N can be applied to solve this problem, however in most situations the possibility of applying purchased fertilizers by farmers is a non adoptable proposition. Consequently, the selection of adapted legumes in association with grasses is a must for the development of a sustainable technology under the socioeconomic conditions of large and small farmers in the region.

Inadequate grazing management:

A degrading pasture, based on non-adapted species in poor soils, may be managed for stability by reducing stocking rates and increasing resting periods to adjust the utilization of the sward to its potential productivity. To do this, it is necessary for the manager to constantly know about the immediate future potential productivity of its pastures in response to the seasons and to grazing management. Resulting in management schemes highly complex and unreliable at farmers level. Normal farmers will find impossible to manage such pastures under the degrading trend; more so because it implies a normal reduction of productivity of the sward, while the demand of forage is actually increasing because of the natural growing of the herd. As mentioned before, new adapted deep rooting aggressive germplasm is basic for the development of sustainable pastures in the region. However even these may be degradable under poor management conditions.

An appropriate grazing management as well as low levels of maintenance fertilization are necessary to optimize the utilization of the grass/legume mixtures, and the persistence of the components of the associated pastures, to maximize nutrient recycling for highly sustainable pastures systems.

Weed invasion and woody regrowth:

This is a spectacular problem, regarded by farmers as a main problem of pastures in the humid pastures. However rather than a cause, weed invasion is a consequence of the lack of adaptation, lack of vigour and competitive ability of the planted species, together with unappropriate management (controlled grazing and fertilizers). If the previous main causes of pasture degradation are solved or managed, lower levels of weed invasion should be expected. However in such a vigorous ecosystem, weed invasion may always be an important problem as in any agricultural production system.

HOW TO SOLVE IT

One option in solving the degradation problem is to use high input technology, meaning the application of ammendment (liming), fertilizers to correct soil fertility deficiencies and to control weeds, pests and diseases to maintain high productivity pastures in the region. The technology for this solution is mostly available. The resulting production systems may then be ecologycally highly justifiable, however economically questionable. More so, in the developing countries of the region where availability of capital for farmers and input/output

prices are normally unfavorable for the adoption of such high input technologies.

The other option, a most difficult one, is to develop a new grass/legume low input pasture technology based on an adapted (to soil, climate and biotic factor) component with higher potential productivity and sustainability. This technology must be suitable for the beef, dual purpose and mixed (crops and cattle) production systems predominant in the region. These new technologies, in order to suit the present situation of pastures in the Amazon should in addition be able to replace already degraded lands for productive sustainable pastures. This is no doubt an immense challenge for scientists working in the region. The potential impact and pay off of the new technological options is ample. Productive, sustainable and adoptable pastures would allow higher cattle productivity levels, intensification of land use and reduce the land clearing pressure of the rainforest.

a. Research Strategies

The aim of the Tropical Pastures Program of CIAT and RIEPT (Red Internacional de Evaluación de Pastos Tropicales) in the Amazon region with a major screening site and a technology development center in cooperation with the national programs (INIPA and IVITA) at Pucallpa, Peru, and several sites throughout the region in cooperation with several national programs (ICA, EMBRAPA, INIAP,...) in Peru, Colombia, Ecuador and Brazil, is to develop new low input technology options of

high productivity and sustainability for the sound ecological and economical utilization of already degraded land of the humid tropics.

The main strategies are:

(1) to develop new adapted pasture grass and legume germplasm adapted to the low fertility and highly acid soils of the region (Oxisols and Ultisols) and resistant to the predominant pest and diseases in the ecosystem. Priority is given to select material for pest and disease resistance (spittlebug in Brachiaria spp., anthracnose in Stylosanthes spp., Rhizoctonia in Centrosema spp., etc.); seedling vigour to compete and withstand the initial aggressiveness of weed invasion at the establishment phase; materials having mechanisms for resiliency (high seed production, stolons, ryzomes, etc.). In addition the legumes should be efficient in N fixation and compatible with aggressive grasses.

The new associations of legumes and grasses should be of high quality and high palatability throughout the year since dry season is only a minor environmental constraint in the ecosystem.

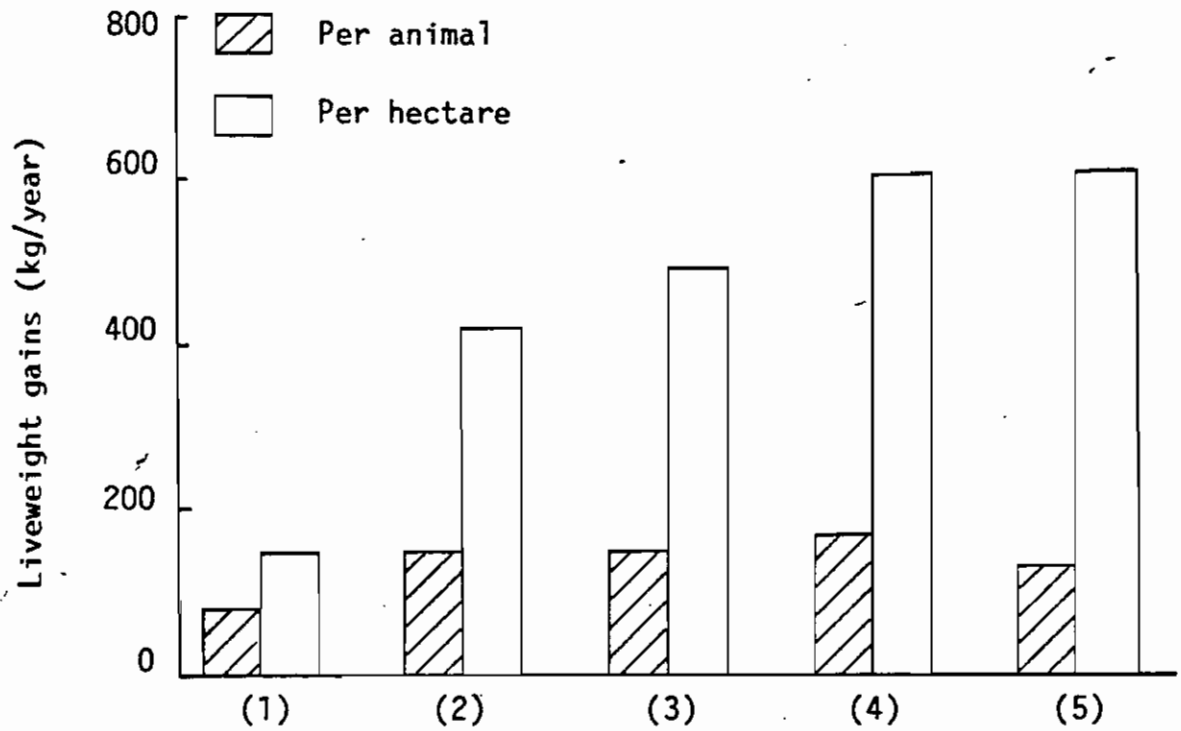
(2) To develop the appropriate low input techniques for the reclamation (weed control and improvement of chemical and physical characteristics of the soil) of already degraded lands with emphasis in highly disturbed areas, in terms of the ecological succession.

(3) The development of the appropriate management principles and techniques to optimize the pasture utilization, biological N fixation and nutrient recycling for highly productive and sustainable pastures and forages within the context of the production systems.

(4) To validate and promote the new technological options to farmers in horizontal cooperation with and among national research and developing agencies.

b. Potential productivity of the new technology.

Figure 1 presents an average of more than 5 years of liveweight gains of several pastures options in the Amazon (Pucallpa and Yurimaguas). The traditional pasture Hyparrhenia rufa produces about 90 kg/head and about 100 kg/ha; the same grass with the association of Stylosanthes guianensis and the application of 20 kg of P_2O_5, duplicates productivity per animal and productivity per ha. New grass/legume associations such as Andropogon gayanus with Stylosanthes guianensis cv. Pucallpa or with Centrosema pubescens CIAT 437 and Brachiaria decumbens with Desmodium ovalifolium are able to further increase productivity per hectare increasing carrying capacity of the pastures. Some of these pastures are able to produce more than 500 kg per ha with only minimum input and management. These are the first new RIEPT options meant to make important impact in the preservation of the ecosystem. These new technology options when commercially available, should replace already degraded lands for productive and sustainable



(1) H. rufa
(2) H. rufa + S. guianensis
(3) A. gayanus + S. guianensis
(4) A. gayanus + C. pubescens
(5) B. decumbens + D. ovalifolium

Sources: Toledo and Morales (1979) and Reategui et al. (1985)

FIGURE 1. LIVEWEIGHT GAINS OF SEVERAL PASTURE OPTIONS IN THE PERUVIAN AMAZON.

pastures, allowing a sound ecological and economical development of the cattle industry in these regions.

c. Silvopastoral system

It should be recognized that today most of the cattle in the region is on open pastures. However, research should also consider the development of integrated silvopastoral systems for higher sustainability. Consequently, some efforts are being done with the screening and development of new germplasm options tolerant to shade. These materials are expected to be integrated into silvopastoral systems in association with plantations such as coconut palm, oil palm, rubber, etc. Also, an important effort is required to select N fixing and successful trees adapted to the high Al acid poor soils of the region.

In the development of these new options, scientists should not forget that shade tolerance is not the only required character of grasses and legumes to fit within tree plantations. Scientists should also study the competition of the pasture species with the tree plantations, and their positive or negative effect on the productivity and stability of the integrated production system components.

The development of silvopastoral systems for the Amazon, is still in its initial research development. It should be easier to develop grass-legume options for the first years of a plantation, when tree shade, nutrient and water competition is still reduced. It should also

be easier, in the case of plantations such as coconut in which light competition from the tree cannopy at mature stage is only small. The integration of pastures will be harder under a heavy shaded plantation such as rubber or oil palm at its mature stage. In these cases, consideration should be given to reducing the tree density of the plantation to allow the success of grasses and legumes for cattle and sheep production in association with the plantation.

FINAL REMARKS

This presentation breafly reports on the Amazon pasture problems, research aims and initial achievements of the national and international endeavor for the development of a new set of technologies of high productivity and sustainability in the ecosystem. These new options are designed to impact in the region allowing an ecologically and economically sound cattle production in the Amazon. The main challenge of the national and international institutions involved in this effort, is to make these technologies available and adoptable to farmers throughout the region.

REFERENCES

Alvim, P. de T. (1978). A expansao de fronteira agricola no Brasil. Primer Seminario Nacional de Politica Agricola, Brasilia. 32 p.

Bandy, D.E. y Benites, J.R. (1977). Proyecto internacional de suelos tropicales, Yurimaguas, Perú. Ministerio de Alimentación y NCSU. 32 p.

Bushbaker, R.J. (1984). Changes in productivity and nutrient cycling following conversion of Amazon rainforest to pastures. Ph.D. dissertation, Univ. of Georgia, Athens.

Calderón, M. (1983). Insect Pests of tropical forage plants in South America. In: Smith J.A. and Hays, V.W. (eds.) Proceedings of the XIV International Grassland Congress. Lexington, Kentucky, U.S.A. 778-780 pp.

Cochrane, T.T.; Sanchez, L.G.; Azevedo, L.G.; Porras, J.A., and Garver, C.L. (1985). Land in Tropical America. 3 Volumes. CIAT, Colombia. ISBN: 84-89206-39-2.

Ferreira da Silva, L.F. (1978). Influencia de manejo de un ecosistema nas propiedades edaficas dos oxisoles de Tabuleiro. CEPLAC-SUDENE, Brasil. 25 p.

Golley, F.B.; McGinnis, S.T.; Clements, R.G.; Child, G.I.; Denver, M.J. (1976). Mineral cycling in a humid tropical forest ecosystem. T.I.E. Athens, Georgia, U.S.A.

Herrera, R.; Jordan, C.F.; Klinge, H.; Medina, E. (1978). Amazon Ecosystems. Their structure and function with particular emphasis on nutrients. Interciencia 3(4): 223-232.

IBGE. (1920-1980). Anuncivo Estadistico de Brasil.

Nye, P.H. (1961). Organic and nutrient cycles under a moist tropical forest. Plant and Soil 13: 333-346.

Odun, H. and Pigeon, R. (1970). A tropical rainforest. AEC., Washington, U.S.A.

OEA. (1920-1980). América en cifras.

Ramírez, A. y Seré, C. (1987). Características del sistema de producción de ganado de doble propósito y de la adopción y uso del Brachiaria decumbens en el Caquetá. CIAT, Colombia (Informe interno). 116 pp.

Reátegui, K., Ara M. y Schaus, R. (1985). Evaluación bajo pastoreo de asociaciones de gramíneas y leguminosas forrajeras en Yurimaguas, Perú. Pasturas Tropicales. Boletín Vol. 7 No. 3: 11-14.

Riesco, A., De la Torre, M., Reyes, C.; Meini, G.; Huamán, H. y García, M. (1982). Análisis exploratorio de los sistemas de fundo de pequeños productores en la Amazonía, Región Pucallpa. IVITA/UNMSM/CIID. Perú. 47 pp.

Serrao, E.A.; Falesi, I.C., Veiga, J.B., Neto, J.F.T. (1978). Productivity of cultivated pastures on low fertility soils in the Amazon of Brazil. In: P.A. Sanchez and L.E. Tergas (eds.) Pasture Production in Acid Soils of the Tropics. Proceedings of a Seminar held at CIAT, Cali, Colombia 17-21 April, 1978. 195-225 pp.

Seubert, C.E.; Sanchez, P.A.; Valverde, C. (1977). Effect of land clearing methods on soil properties of an Ultisol and crop performance in the Amazon jungle of Peru. Raleigh, North Carolina Agricultural Experiment Station and Min. de Alimentación, Perú. Journal Series Paper No. 500Z. 307-321 pp.

Toledo, J.M. y Ara, M. (1977). Manejo de suelos para pasturas en la selva amazónica. Trabajo preparado para la Reunión Taller FAO-SIDA sobre ordenación y conservación de suelos en América Latina, Lima, Perú, 466 pp.

Toledo, J.M. and Morales, V.A. (1979). Establishment and management of improved pastures in the Peruvian Amazon. In: Sanchjez, P.A. and Tergas, L.E. (eds.) Pasture Production in Acid Soils of the Tropics. Proceedings of a Seminar held at CIAT, Cali, Colombia. 177-194 pp.

Toledo, J.M. and Serrao, E.A. (1982). Producción de pastos y ganado en la Amazonía. En: Hecht, S.B. et al. (eds.). Amazonia, investigación sobre agricultura y uso de tierras. CIAT, Cali, Colombia. 295-324 pp.

Toledo, J.M. (1984). Pasturas en trópico húmedo: Perspectiva global. In: Simposio de Trópico Umido, Belem, Pará, Brasil. 32 p.