THE PLACE OF AGRO-FORESTRY IN MANAGING TROPICAL FORESTS

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SUMMARY

Although agro-forestry has lately received much attention, its relationship to management of tropical forests is far from clear; in fact certain agro-forestry practices are often in open conflict with desirable high forest management, particularly in moist environments. However those agro-forestry practices that provide stability to rural inhabitants, leading to better land use and its conservation, and thefore relieve the pressure on the natural forests, providing firewood and other local and industrial needs, should be promoted. This is borne out from various successful agro-forestry case studies from high rainfall areas of Costa Rica that are described: 1) the adding of a high canopy of the valuable timber tree Cordia alliodora over coffee and cocoa, above a canopy of leguminous shade trees that are kept low by intensive pruning; 2) the addition of different trees within pastures in the lowlands; 3) the favored gradual replacement of pastures by valuable secondary forests through the channeling of natural succession; and 4) the planting of N fixing alder trees, Alnus acuminata in the highlands of Costa Rica's dairy region, under intensive management. The controversial case of "taungya" particularly when it impies conversion of the heterogeneous high forest to monocultures, is discussed. It is argued that taungya is most promising when established on degraded forest or on savannas and that selected tree crops should be established as early as possible jointly with food crops. The success or failure of agro-forestry schemes is linked to the attention given to social and economic aspects that contribute to rural development.

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Agro-forestry has been variously defined and the first newsletter by the International Council for Research in Agro-Forestry (ICRAF) in December 1979, included no less than 9 definitions. An essay on the classification of agro-forestry techniques has also been published (Combe and Budowski, 1979).

In this paper agro-forestry implies that trees are combined in space and/or in time (sequential) with either farm crops or domestic animals or both, and that a stable production system should be achieved (Budowski, 1977).

Agro-forestry has lately attracted great attention, verging almost to become a panacea for many tropical lands, particularly marginal areas. A clarification as to the real merits and limitations is urgently needed.

In the report that in a way lead to the foundation of ICRAF, the leading organization on research in agro-forestry, located in Nairobi, (Bene et al 1977), make the point that "...more than half of all land in the tropics, although too dry, to steep, or too rocky to be classified as arable land, is suitable to the practice of agro-forestry" and this statement is placed in an emphasis box (p. 43). There are a few other statements in this otherwise most interesting and stimulating publication that attract immediate suspicion such as (p. 44)... "wide spaced Alnus jorullensis (alder) on high elevation (2000-3000 m) in pastures in the tropics has increased forage production eight-fold in Latin America, and in addition 10 m^3/ha/year of wood for fuel and industrial use was produced on a 20 year rotation".

Various international organizations are involved in agro-forestry besides ICRAF. Several international meetings on agro-forestry have recently been held and the results of experiences from different parts of the world are

slowly coming in. The Royal Tropical Institute, Amsterdam, held a meeting on agro-forestry in 1978, with 4 papers by experts and discussion. An international workshop on agro-forestry systems, sponsored by the United Nations University (UNU) and CATIE with emphasis on Latin America, was held in Turrialba, Costa Rica in March 1979 (CATIE, 1979). ICRAF sponsored an expert consultation held at its headquarters in Nairobi in 1979, on the subject of "Soils research in agro-forestry" and the proceedings have been published (Mongi and Huxley, 1979). ICRAF also organized an international conference on "International Cooperation in Agro-forestry" in July 1979 (proceedings not yet published). UNU jointly with the University of Chiang-Mai held a second international workshop in Chiang Mai, Thailand, in November 1970 (Proceedings not yet published) and a third workshop by UNU is planned for Africa in 1981. FAO has an ongoing program in agro-forestry and the subject was given great prominence during the World Forestry Congress in Jakarta, 1978. Moreover IUFRO has a special working group SI'07-07 devoted to agro-forestry while UNU has an international program that includes technical meetings, assistance for research and fellowships for candidates of developing countries who go for in-service training at centers of recognized capability. Canada's International Development Research Center (IDRC) has been financing a series of field projects, notably in various African countries covering various research subjects and Switzerland and the Federal Republic of Germany have ongoing technical cooperation programs on this subject.

Two agro-forestry newsletters have recently made their appearance, one in December 1979 by ICRAF, Nairobi and another by CATIE, Turrialba in January 1980. The literature is quickly swelling and while this is desirable, a certain confusion has arisen as to the real benefits of agro-forestry and its impact on rural development. Moreover very little has dealt with the relationship

between agro-forestry and sound management of tropical forests.

Diversity in agro-forestry techniques

The practice is obviously very old. While attending the World Forestry Congress in Indonesia in 1978, delegates in one of the field trips saw frescoes depicting agro-forestry practices many centuries ago*. In a way shifting cultivation is a form of agro-forestry according to the definition used, whenever it is a stable system, which is sometimes the case when population is low and forests plentiful. Forest dwellers in tropical countries often look at the forest as a reserve for shifting and this has often lead to hostile attitudes when other management practices and restrictions on local inhabitants are introduced into the forest. For example, it is reported that in Papua New Guinea, farmers have a special knowledge of successional patterns following abandonment after cropping, favoring certain tree crops that are known to better restore fertility (Clark, 1971 p. 63).

Lately a series of papers have appeared revalidating indigenous agro-forestry systems notably for Java (Wiersum, 1979) and for Mexico (Fuentes Flores, 1979). Obviously it is not easy to quantify and assess these systems because of the many variables involved and the difficulty of setting up an

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* WADSWORTH, F.H. Personal communication and photographs, 1978.

experimental design with controlled treatments. The need to coordinate research on agro-forestry techniques is in fact the main justification for setting up ICRAF (King and Chandler, 1978). One such experiment at CATIE includes as many as 18 replicated treatments involving annual food plants, pastures, perennial food crops, timber trees and trees planted strictly for shade and organic matter; it is now 4 1/2 years old and still awaits a careful analysis and evaluation concerning growth and development rates, soils, plant architecture, yields, phytosanitary aspects and economics (Enríquez, 1979). The variety and possibilities of plants that can be associated has been described in a literature review by Zaffaroni and Enríquez (1979) and there is a review of practical experiencies in Latin American countries (Budowski, 1979).

By far the largest modality of agro-forestry is the taungya system which aims basically at an equitable social and legal contract through which the owner of the land permits farmers to cultivate food crops in exchange for the simultaneous planting and early maintenance of desirable tree crops. There are many variations in the taungya system depending on the timing to establish trees whether planted jointly with the first food crops or at a later stage, whether workers get the benefit of their food crops or not, often called respectively "social" taungya and "departamental taungya" -in that later case, they are entitled to a wage and not to the food- and the choice and ultimate function and destiny of the tree crop (soil improvement, local uses, nearby industries for export, etc.). Combinations involving cattle and trees can also assume a great variety. The role of trees in improving the physical and chemical conditions of t soil can become an important factor particularly in humid areas and so can browsin

and provision

of protein supplement, particularly at a critical period. Cattle can also help suppress weeds that compete with trees.

The variations of agro-forestry systems, the various benefits and drawbacks, the changing attitude of different people towards certain practices, all contribute to a complicated picture.

However the focus of the present paper will be on how agro-forestry relates to the management of tropical forests particularly humid forests and as such, the approach will be to analyze cases where agro-forestry is beneficial or harmful, to the management of tropical high forest.

Management of tropical moist forests and plantations

Ideally, forest management when successful implies that forestry produces biological, social and economic benefits. In practice, examples of successful management vary greatly and most interventions in the natural forest for example, are synonymous with highgrading or other forms of downgrading if not outrigh mismanagement. Rarely are long term considerations applied. For the highly heterogeneous humid tropical forests, success stories are very scarce and the few that are described involve techniques which are rarely applied (careful regeneration counting, selection of species, weeding at the appropriate moment, etc.). Better success has been achieved with secondary forests for instance in the Buenaventura area of Colombia by Cartón de Colombia or at CATIE (see Combe and Gewald, 1979, pp. 217-228), enrichment planting and certain types of management of natural forests dominated by one or a few species such as swamp forests, gallery forests, mangroves or others, usually characterized by special edaphic conditions.

Another matter refers of course to plantation forestry and here there are success stories as well as failures; many of them, particularly successes, are well documented. Since planted trees can often be combined with annual or perennial food crops or grasses, there is an immediate relation with agro-forestry.

The following arbitrary headings constitute an attempt to assess the relation between agro-forestry and various types of tropical moist forest management as well as plantations. A few observations are necessary to clarify certain aspects of such relationship.

Agro-forestry and the disappearance of tropical moist forests

A major concern of tropical forestry is the rapid disappearance of the last remnants of the tropical moist forests throughout the world as it has been recently reviewed by Myers (1980). Obviously any favourable relationship between agro-forestry and tropical moist forests would imply the braking of the rate of destruction and eventually some stabilization of land use concerning natural forests areas that must remain for protection and other services, forests for wood production and agricultural (and possibly urban) lands.

In this connection whatever agro-forestry can achieve, that would relieve the pressure on, and avoid the destruction of, tropical moist forests, should be viewed as favorable.

Shifting cultivation clearly is brought into focus and one might reason, as many have done before, that intensification of production per unit of surface without deterioration of the long term production capacity should be a prime objective. The same can be said for stabilization of rural populations and their impact on the natural forest. In this connection much greater attention

must be given to social and health problems. Finally there is the important relationship of job generation from the management of the forest and the avoidance of absolute dependence by rural populations from their plots of shifting agriculture to provide food, a matter that has lately been compounded by greater competition for land and higher survival rates of children. If management of the tropical moist forest provides jobs and salaries for local inhabitants, it can be reasoned that less area is necessary to provide the basic food for them, provided that agriculture in the more climatically and edaphically amenable areas is intensified and that food distribution is adequate.

Various types of relation between agro-forestry systems and the management of tropical moist forest

Let us examine a few case studies when timber and food is produced outside but close to forest and therefore relieves the pressure on the forest.

1. Coffee or cocoa and one or two strata of "shade" trees

This example is well known in many tropical countries. Curiously the role of the trees over coffee or cocoa has not been thoroughly analyzed but it is clear that they produce much more than shade and that their beneficial and detrimental effects cover a very wide range. In fact a strong discussion concerning the value of shade trees over coffee is usually prevalent in most coffee producting countries. It is usually accepted that in comparison with open grown coffee, shade trees provide protection against wind, improve microclimate add organic matter to the soil and, in the case of N-fixing tree species, add N compounds; they also trap and recycle nutrients, a benefit that is particularly appreciated if the root system is deeper than in coffee ("pumping" effect).

They also produce food from some of the trees (notably from scattered Citrus trees, a few palms, and the more prevalent Inga spp. trees) and they produce firewood, poles, posts, and ocassionally some timber. It is also usually accepted that less fertilizer is necessary for shaded coffee and the life cicle of the coffee trees is longer. Another important effect concerns the soil, which remains well protected and less prone to erosion (Fuentes Flores, 1979).

Against this, it is argued that coffee without shade, planted at very close distances (self-shading), heavily fertilized and carefully weeded (with herbicides), produces higher yields; that shade trees compete for water, producing strees at critical periods during the dryer period; that traditional shade trees such as fully grown Erythrina spp., Inga spp. and Ficus spp. are difficult and costly to prune and, when eventually uprooted, may cause considerable damage to the crop.

Lately in several Latin American countries, a variety of techniques have evolved to add a third canopy of valuable timber trees over a middle canopy of low leguminous trees, planted strictly for shade and periodically pruned. In Costa Rica and Ecuador the preferred timber tree is Cordia alliodora that regenerates naturally in coffee plantations and is left to overtop the coffee and low shade trees.

The practice is found both in coffee and cocoa but has been particularly well developed for coffee where it is coupled with the careful and drastic pruning of the shade trees. In the Turrialba area of Costa Rica, where rainfall averages 2674 mm a year, Erythrina poeppigiana is the prevalent shade tree; it is usually planted by large cuttings (derived from other shade trees -a product that should be added to the list of benefits from shade trees cited above) that easily take root; these Erythrina trees are kept low, about 3 meters, over the coffee, by very intensive pruning (pollarding), twice a year. Such heavy pruning is synchronized with the flowering and fruiting periods of

coffee and is done after coffee harvesting. Erythrina fixes N through the activities of Rhizobium in the very young roots. Measurements at Turrialba show that the total amount of time spent for pruning one Erythrina tree is around 90 seconds and about 4 more minutes are used to chop and spread the foliage over the ground to act as a mulch.

While most coffee plantations only have one additional canopy of Erythrina, the practice of adding a third high canopy of Cordia alliodora is spreading, usually at elevations between 500 to 800 meters above sea level which corresponds to the lower limits of arabica coffee. Cordia alliodora has a notably small crown, a relatively good form and a self pruning habit. The tree is decidious, of very rapid growth and it loses its leaves during the drier period from February to April, even in areas of 2600 mm of rainfall or more. Volume measurements show that the combination of coffee, Erythrina and Cordia, the latter established by natural regeneration, produces the following amount of timber:

Table 1. Growth of a naturally established stand of Cordia alliodora over coffee shaded by Erythrina poeppigiana, the latter planted by large cuttings every 6 m and heavily pruned twice a year (after Combe and Gewald, 1979). Conditions of Turrialba are 2674 mm of rainfall and a mean annual temperature of 22.2°C.

	1977	1979
Estimated age	15 years	17 years
Number of trees per ha.	228	228
Average dhb(cm)	28.9	30.7
Average height (m)	22.5	22.9
Total volume with bark (m^3/ha)	162.3	189.0
Mean annual increment with bark (m^3/ha/year)	10.82	11.12

Logging trials showed that Cordia trees can be felled easily between the rows and hauled to the road by oxen. Logging is best practiced before the pruning of coffee and Erythrina. As yet no definite comparable data are available on the production of coffee associated or not with Cordia.

Measurements of Cordia alliodora trees over cocoa in the Costa Rican lowlands showed even higher increments.

One plot in the wet Atlantic coast of Costa Rica on alluvial soils showed the following evolution of a Cordia alliodora stand over cocoa and a few other shade trees over a period of two years:

Table 2. Growth of a naturally established stand of Cordia alliodora over cocoa (and a few other low shade trees), Home Creek, Costa Rica, (after unpublished data, Natural Renewable Resources, CATIE, Turrialba, Costa Rica, 1979). Rainfall is around 3000 mm and mean annual temperature around 24.5°C.

	15 April 1977	16 March 1979	Current annual increment**
Estimated age in years	20-25	22-27	
Trees per ha.	120	100*	
Average dhb in cm**	41.1	43.1	1.0
Average height in m**	34.0	35.2	0.6
Total volume in m^3/ha with bark	271.1	257.0*	14.8

* The figure decreased because many trees were harvested in the 2 year period.

** Based on the same trees measured in 1977 and 1979.

2. Timber trees in pastures in wet lowlands

It is common practice in many tropical moist environments that trees are left to grow when pastures are weeded. The relationship of trees and grass has never been carefully investigated although the combination is extremely widespread. The practice has been observed by the author in Panama, Costa Rica, Nicaragua, Honduras, Guatemala, Mexico, Colombia, Ecuador and Venezuela. In Costa Rica, Cordia alliodora and to a lesser degree Cedrela odorata and some palms are the preferred trees.

One plot established in eastern Costa Rica gave the following results:

Table 3. Growth of naturally established Cordia alliodora trees in man-made pastures (Combe 1979). Cahuita, (sea level), 3000 mm rainfall, mean annual temperature of 25°C.

	Date		Current annual increment**
	15 April 1977	16 March 1979	
Number of trees per hectare	200	190*	-
Estimated age	25-30	27-32	-
Average dhb in cm	37.5	38.6	0.55
Average height in m	34.5	35.0	0.25
Total volume in m^3/ha (with bark)	380.4	389.1*	13.5

* Some trees were harvested in the two year period.

**Based on measurements on the same trees.

As it can be seen the volume is considerable and in fact a large amount of the Cordia alliodora logs in the country's sawmills, come from these pastures (as well as from the cocoa and coffee combinations).

3. From natural moist forest, to pasture, to secondary forest in wet lowlands

It is interesting to notice that in many pastures in Costa Rica, established in high rainfall areas in the lowlands, there is an ever increasing problem of encroachment by woody weeds. With the lack of a long enough dry season, burning is out of question. Different intensities of trees combined with pastures can often be seen, ranging from an open landscape with very few trees to secondary forests that admit practically no grazing. Eventually grazing is abandoned and a secondary forest develops. One measured plot of the latter with 4100 mm of rainfall and a mean annual temperature of 24°C corresponds to pastures abandoned approximately 15 years ago; it showed a floristic composition of 9 trees species, all commercial. Total volume was 412 m^3/ha from 400 trees, above 20 cm dhb (CATIE, 1979, pp. 209-210). Although no long-term measurements exist, the forest looks very promising in growth, yield and commercial value and appears to respond well to simple management practices.

4. Alder and fertilized grasses in the dairy region in the highlands of Costa Rica

Another spectacular development has taken shape in the highlands of Costa Rica between 1400 and 2500 m elevation, where the main dairy region is located, mostly on the basis of a local alder, Alnus acuminata, planted within pastures that are grazed (Pennisetum clandestinum) or cutgrass (Pennisetum purpureum and Axonopus scoparius). All the grasses are intensively managed.

The small enclosures for grazing are fertilized and rotated every 20-30 days. Spacing of the alder varies from 8 x 8 m to 12 x 12 m or even more. Alder also fixes N from the air through large nodules that are easily visible on the roots. A few measurements show the following yields in two plots in the highlands of Costa Rica.

Table 4. Growth of alder, Alnus acuminata in two plots in the highlands of Costa Rica, associated with pastures and cutgrass. (After Combe, 1979). Rainfall is around 3500 mm and mean annual temperature between 16 and 18°C, according to elevation.

	Las Nubes	San Rafael
Elevation above sea level	1700	1450
Pasture associated with alder	Pennisetum clandestinum (grazed)	P. purpureum (cutgrass)
Age in years	15	6
Spacing of trees in m	8x12 and up to 10x14	7x9 and 7x11
Density per ha initial	132 approx.	---
present	78	159 and 130
Height in m (26 trees)	22.0	10.0
Mean annual height increment in m	1.47	1.67
dbh in cm (25 trees)	44.8	17.0
Mean annual dbh increment in cm	2.29	2.83

As can be seen this is outstanding growth although admittedly on good volcanic soils. The wide spacing still allows an excellent development of the grass although farmers ocassionally complain that excessive shade hampers their pastures and that raindrops originated from the high branches of the alder trees cause damage. At any rate the potential for developing is great and for Costa Rica it has been estimated that about 60 000 hectares could be devoted to this combination. A program to encourage farmers to plant more alder is being implemented and a popular manual based on the research work by Poschen (1980) is presently being written. The trees are usually harvested on a 15-20 year rotation

and the wood is in large demand for constructions in the highlands, for boxes, firewood and, lately, for certain types of shoes.

Taungya and tropical forest management

This is possibly the most controversial aspects in the relation between agro-forestry and tropical forest management and is likely to be remain so for many years. One reason is that taungya leads to the establishment of mono-cultures of one or few species of trees at the expense of the high natural or secondary heterogeneous forests. It has often been argued that many of these original forests, instead of being "converted", could well be more advantageously managed, instead of drastically replacing them by "vulnerable" monocultures, particularly in the light of new developments that allow the harvesting of all species of trees in a natural forest. However the need for food derived from taungya and the deeply rooted practice of shifting agriculture often makes it very difficult, if not impossible, to have taungya schemes carefully applied by local populations. These often have no other alternatives than opening up and converting high forests to field with food crops and let these revert to secondary forests or low brush. Eventually the last remnants of natural forests will thus disappear.

The theme has been the subject of countless and conflicting publications. However, as data come in, a few trends can be detected that may shed some light on some of the controversial aspects:

1. It appears more desirable to establish plantations through taungya at the expense of very degraded forest, secondary brush or even certain savannas, rather than converting natural high forests. For savannas, there exist a variety of native techniques to increase fertility such as burning of mounds of dry vegetation covered with a thin layer of soil where trees are planted together with food crops as described by Dubois (1979, pp. 84-90). The method has also successfully been used in Turrialba for direct seeding of Cordia alliodora but without associating food crops (Combe and Gewald, 1979, pp. 52-53).

2. When establishing trees with crops, many combinations and sequences are possible. However it appears profitable, both ecologically and economically to plant trees as early as possible, jointly with the crops and not a few years later, when there is soil degradation and invasion of excessive weeds. Experiences at CATIE, Turrialba show great promises in combining for two years (until the young trees close the canopy), several traditional crops such as corn and beans, with well known plantation trees such as Gmelina arborea, Cordia alliodora, Terminalia ivorensis and Eucalyptus deglupta (Combe and Gewald, 1979).

3. Successful taungya depends very much on the resolution of social, health and economic (for instance marketing) problems.

Conclusions

From the foregoing examples, by no means to be considered exhaustive, a few conclusions can be draws.

1. The next decades are likely to witness increased conflicts for land use between farmers needing land for food production, and foresters as well as conservationists trying to maintain the forest as a capital for wood production, genetic and environmental resources, and other goods and influences. To obviate this conflict, foresters should take a much closer look at farmers' needs and customs and should join efforts in stabilizing rural populations. This will demand a broader look at and larger involvement in rural development schemes. Above all, the successful establishment of permanent settlements close to forests should be aimed at. In this connection, agro-forestry can and should play a much

larger role than hitherto based on the fact that forest management whether based on natural forests or plantations, offers seasonal or full employment to a pool of laborers and that it may provide a formula for better land tenure. At any rate a much closer integration by forest industries with rural populations living close or within forest areas is highly desirable.

2. Production of wood for industry or for local needs (firewood, poles, posts), is highly desirable on any kind of non-forested land where this can be advantageously combined with food crops or pastures. The guiding principle is intensification of agricultural as well as forest production on these lands whenever this is feasable without degradation. This will relieve the pressure on natural forests and provide rural inhabitants with their basic necessities. If such agro-forestry schemes also contribute to permanently settle farmers, they may be worth subventioning, through economic, social or other measures. The Costa Rican experience shows that certain trees can be planted at wide spacing on very productive lands together with food crops or grasses, particularly in areas of high rainfall where there is no competition for water.

3. Research on tree species adapted for specific agro-forestry combinations appears promising, particularly when based on existing successful practices. The special characteristics of desirable "agro-forestry" trees must be taken into account as well as the local preferences.

4. Both research and training in the field of agro-forestry demand an interdisciplinary approach that is often lacking among foresters.

REFERENCES

1. BENE, J.G., BEALL, H.W. and COTE, A. 1977. Trees, food and people, land management in the tropics. Ottawa, IDRC. 52 p.

2. BUDOWSKI, G. 1977. Agro-forestry in the humid tropics. A programme of work. Report submitted to IDRC. Turrialba, Costa Rica, CATIE. 24 p. (mimeo).

3. _____, 1979. National, bilateral and multilateral agro-forestry projects in Central and South America. International Conference on "International Cooperation in Agro-forestry", 15-23 July 1979. Nairobi, Kenya. 24 p. + 3 p. appendixes (in press).

4. CATIE. 1979. Workshop on Agro-forestry Systems in Latin America. Turrialba, Costa Rica. March 26-30, 1979. Proceedings. 220 p.

5. CATIE, UNU and IUFRO. 1980. Agro-forestry. Turrialba, Costa Rica. No. 1. 12 p.

6. CLARK, W.C. 1971. Place and people; an ecology of New Guinean community. Canberra, Australian National University Press. 265 p.

7. COMBE, J. 1979. Combinaciones silvo-pastoriles en zonas altas de producción de leche en Costa Rica. In Proceedings Simposio Internacional sobre las Ciencias Forestales y su Contribución al Desarrollo de la América Tropical. 11-17 Octubre de 1979. Notes for excursion No. 3. 4 p. (In press).

8. COMBE, J. and GEWALD, N. 1979. Guía de campo de los ensayos forestales del CATIE en Turrialba, Costa Rica. CATIE, Turrialba, Costa Rica. 378 p.

9. COMBE, J. and BUDOWSKI, G. 1979. Classification of agro-forestry techniques In CATIE, 1979. Workshop on Agro-forestry Systems in Latin America. Turrialba, Costa Rica. March 26-30, 1979. Proceedings. pp. 17-47.

10. DUBOIS, J. 1979. In CATIE 1979. Workshop on Agro-forestry Systems in Latin America. Turrialba, Costa Rica. March 26-30, 1979. Proceedings. pp. 84-90.

11. ENRIQUEZ, G. 1979. In CATIE 1979. Workshop on Agro-forestry Systems in Latin America. Turrialba, Costa Rica. March 26-30, 1979. Proceedings. pp. 193-195.

12. FUENTES FLORES, R. 1979. In CATIE, 1979. Workshop on Agro-forestry Systems in Latin America. Turrialba, Costa Rica. March 26-30, 1979. Proceedings. pp. 60-72.

13. ICRAF. 1979. Newsletter; news and comments from the International Council for Research in Agro-forestry 1(1):1-4.

14. KING, K.F.S. and CHANDLER, T. 1978. The wasted lands. ICRAF, Nairobi, 35 p.

15. MONGI, H.O. and HUXLEY, P.A. editors. Soil research in agro-forestry. Proceedings of an expert consultation held at the International Council for Research in Agro-forestry in Nairobi, March 26-30, 1979. ICRAF, Nairobi. 584 p. + 2 p. annex.

16. MYERS, N. 1980. Conversion of tropical moist forest. Washington, D.C. National Academy of Sciences. 1980. 205 p.

17. POSCHEN, P. 1980. El jaúl con pasto. Ansatze eines silvo-pastorales Systems auf Viehweiden der submontanen Stufe in Costa Rica. Diplomarbeit. University of Freiburg (Fed. Rep. of Germany), Faculty of Forest Sciences. 139 p.

18. ROYAL TROPICAL INSTITUTE, Amsterdam. 1978. Agro-forestry; Proceedings of the 50th "Tropische Landbouwdag". Bulletin 303, Department of Agricultural Research, Amsterdam. 47 p.

19. WIERSUM, K.F. 1979. Possibilities for use and development of indigenous agro-forestry systems for sustained land-use on Java. Paper prepared for the V International Symposium on Tropical Ecology, Kuala Lumpur, 1979. 7 p. (mimeo).

20. ZAFFARONI, E. and ENRIQUEZ, G. 1979. Asociación de cultivos perennes, una alternativa de diversificación en áreas tropicales para pequeños agricultores. CATIE, Turrialba, Costa Rica. 17 p.

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