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# AGROFORESTRY POTENTIAL IN THE SIERRA DE LAS MINAS BIOSPHERE RESERVE, GUATEMALA

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Forest Resources 5703
Agroforestry: Sustainable Production and Watershed Management

13 ~~January~~ MARCH 1992

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## Introduction: The Concept of Biosphere Reserves

In the past few decades, Western conservationists have realized that it is futile to transport their concept of national parks to developing countries, especially in the tropics. They found that simply drawing borders around an area and kicking people out would not meet their objective of conserving biodiversity. Local people, many of them poor, responded with anger, and they rarely respected park boundaries. Funding for parks was low, so it was nearly impossible to police the boundaries. Deforestation and encroachment continued. Many conservation biologists realized that an alternative to the traditional national park was needed. (Gregg 1991).

The idea of the biosphere reserve emerged, and by 1986, it was defined as something quite different from the national park. Batisse (1986, as cited in Olsen, 1989.) argued that biosphere reserves have three basic roles 1) A conservation role, 2) A development role, 3) a research and training role. The development role strongly differentiated it from traditional parks. Instead of viewing local people as adversaries, they would be seen as important participants in regional and reserve development plans. The reserve

would become a pilot area where research, conservation, and development were combined.(Halffter and Ezcurra 1987) Some reserves would attempt to be catalysts for sustainable development in their region. (Santana et al 1989).

Biosphere Reserves were to carry out their different roles through a system of zoning. The generally accepted or suggested scheme for biosphere reserves is depicted in figure 1, after Batisse (1986) as cited in Gregg, 1991. The idea is to have a strictly delineated core area that is minimally disturbed. Surrounding the core area is the buffer zone, which may support experimental research, recreation, silvaculture and agriculture, scattered settlements, and other fairly low intensity uses. Moving further out is the transition or cooperation zone, which supports regionally characteristic uses and is the main area for involving local people in sustainable patterns of development, and for implementing extension and eduction programs which will both help improve their lives and generate enthusiasm for the reserve. This area is usually not mapped, but it may contain delineated research and demonstration areas.

At present, more than 270 biosphere reserves have been declared in 70 countries. (Gregg 1991). However, Gregg (1991) points out that reserve projects often emphasize their core areas more than their buffer and transition zones. Plans for these areas are often vague, probably because it is the most challenging and new part of reserve management. Sustainable agriculture is often mentioned as an important component, but very little specific information is given.

More research needs to be done on specific practices that can meet the objectives of conservation and sustainable development.

Because agroforestry can be a way to increase productivity of small farms in the tropics while enhancing the environment, it seems that it could be an important component of biosphere reserves, primarily in the transition and buffer zones. It could have both direct effects, like decreasing soil erosion and stabilizing watersheds, and indirect effects, like decreasing the need for people to encroach on forests. Unfortunately, the word agroforestry was not found in a review of the literature on Central American and Mexican biosphere reserves (Torres et al 1989, Olsen 1989, Houseal et al1989, Carillo-Barrios-Gomez et al 1989, Santana 1989).

The purpose of this paper is to explore the potential of agroforestry on a specific project: the Sierra de las Minas Biosphere Reserve in Guatemala.

## The Sierra de Las Minas Biosphere Reserve

In October of 1990, a region in the Sierra de las Minas mountains in east central Guatemala was formally declared a biosphere reserve. A private organization, Fundacion Defensores de la Naturaleza, was appointed the coordinator and administrator of the area. Many NG0's such as the Nature Conservancy, The World Wildlife Fund, and CARE are involved in the project, along with USAID and many Guatemalan agencies and groups. (Defensores, Promotional sheet, date not stated, Defensores 1992).

Physical and Biological Attributes:

[1]The Sierra de las Minas Biosphere Reserve encompasses 322,500[2] acres (129,000 hectares) of extremely steep mountainous country in east central Guatemala (see maps). The reserve is long and fairly narrow, essentially covering a cross section of one ridge. Elevations range from 150 meters to 3015 meters, and this variation results in eight distinct life zones. It is one of the most biologically diverse areas of Guatemala, containing large tracts of tropical humid and cloud forests. The area is seen as essential habitat for the endangered national bird of Guatemala, the Resplendent Quetzal. 400 other species of birds inhabit the area, including the endangered harpy eagle, and 20-40% of these species are neotropical migrants. (US Forest Service 1991). The area is also known to be one of the most important reserves of tropical conifer germplasm in the world. 17 species and three genera of conifers are found here, and some of these, such as *Pinus caribea* varieties, are used for reforestation programs in many parts of the world. The germplasm in the reserve may be important for breeding and improvement efforts (Defensores 1992; Perry, 1991).

The reserve is also a very important source of water. 63 rivers run down the north and south slopes of the main ridge, and the

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[1]Much of the information on the reserve is taken from "Fundacion Defensores de la Naturaleza -- Reserva de la Biosphera Sierra de las Minas: Plan Opertivo." Several other sources are noted. I will admit that some mis-interpretations are possible -- I have never had formal training in Spanish.

[2]I suspect that this figure refers only to the core area of the reserve, and the total area of the reserve is actually much larger. One account stated that 90,000 hectares of the core area is privately owned and equals 2/3 of the total core area. (Defensores promotional sheet, date not stated).

southern rivers provide water for agriculture in the Motagua Valley-- the driest part of Guatemala. Subsistence farming occurs in the reserve, and crops such as maize and beans are grown. Export crops such as coffee, tobacco, tomatoes, melon, cardamom, and rice are grown in the lower parts of the reserve and around it. (Defensores, 1992).

Zoning of the Reserve:

Map 3 shows the zoning of the Sierra de las Minas Biosphere Reserve. The core area largely consists of forest. It is difficult to tell exactly what the other zones correspond to, when comparing it to the land use and vegetation map (map 4). It may be that delineated boundaries of zones will be worked out as more information is gathered, and the zones on the map are given just to illustrate the concept of biosphere reserves (The map was taken from an annual report of Defensores de la Naturaleza, definitely not intended for scientific purposes). Curiously, the zoning of the Sierra de las Minas reserve differs in one respect from the generally accepted conceptual scheme for biosphere reserves, by its inclusion of the Zona de Uso de Sostenido (sustainable use area) in the area immediately around the core area. Perhaps this area could be considered a sub-unit of the buffer zone. It may very well be that much of the buffer zone is degraded and needs to reclaimed and restored. Though the zonation map doesn't designate a transition zone, it is evident that the area around the buffer zone has been considered, as the land uses in this area were mapped.

Threats and Problems:

Despite the extraordinary riches of the reserve, the area is far from pristine and many factors threaten its ecological integrity (See map 4). Population pressure and deforestation is a major problem. On

the north side of the reserve, Q'ekchi and Pocomchi Indians have been forced off their more fertile lands down slope (by "political instability"), and are practicing unsustainable slash and burn agriculture on higher and higher reaches of the reserve. Note the fingers of orange moving up slope into the green areas on the land use map. The red areas are inholdings of squatters ("Asentamientos humanos"-- sitting humans). The grey areas indicate eroded land, although I could not determine whether this is caused by agriculture or logging . The south side of the reserve is threatened by expanding cattle ranching (violet) and agriculture, non sustainable forestry practices, illegal hunting, and soil erosion.

Logging has also taken its toll. A major problem is that 55% of the reserve is privately owned, and all logging concessions that were issued before the reserve was declared are still valid. (Defensores de la Naturaleza, promotional sheet, and "Plan Opertivo" 1992). I do not know the extent to which logging has taken place, but fairly major portions of the forest on the land use map are either "open" or "dispersed" (cross hatched and stippled areas), and this could very well be from logging. A huge pulp mill in the nearby village of El Rancho is scheduled to be reopened (it was closed in 1986 because of financial problems), and this would certainly increase the logging pressure in the region (Gardner 1990a: 7, Faust 1992).

Aside from the direct threats to the reserve, an overarching problem is simply a lack of funding, knowledge, and expertise to be used in conservation and sustainable development efforts. Reportedly, there are only 15 biologists working in Guatemala, and

the resource guards working on the reserve have no higher than a third grade education (Gerdes 1992). Despite this, significant work has been done, through a combination of international and Guatemalan effort.

Management Goals and Objectives of the Reserve:

In response to the general problems discussed above, Defensores de la Naturaleza has developed overall goals and strategies to overcome them. The general goals of the reserve follow:

1) Protection of the forests and biodiversity in the reserve.

2) Maintenance and management of water production.

3) Sustainable development of natural resources in and around the reserve to improve the lives of the local people.

4) Promotion of scientific investigation.

5) Education of the Guatemalan public.

Major strategies to carry out these objectives include:

1) Marking of boundaries, zonation, and mapping.
At present there are 18 resource guards working on the reserve; boundary marking and identification of special areas of concern are major activities. Establishing agreements with private landowners or purchasing private land is occurring, and 3 check points on roads have also been established. Construction of trails and design of public access areas are planned.

2) Public relations, education, extension, and development of sustainable uses of the reserve.

This involves educating local people about the importance of the reserve, involving them in management plans, and giving them assistance in sustainable agriculture, and other sustainable uses of the reserve. A major part of this is curtailing slash and burn agriculture, and helping the indigenous population to gain land tenure where they can develop sustainable practices. Demonstration plots will be set up, and training workshops and exchange experiences will be conducted. Development of tourism as a sustainable use, sustainable forestry, marketing of conifer seeds, and germplasm conservation are also important components. Careful diagnosis of the socioeconomics of the area is planned, along with coordination all interested parties.

3) Scientific Investigation and Monitoring.

This includes research on tropical ecology and sustainable uses, and monitoring of biodiversity and human impacts on the reserve.

4) Effective administration and management.

This includes developing effective and careful plans, supervision and evaluation of staff, administration of funds, and management and development of physical resources.

Agroforestry could be an important component of strategy 2, above. A review of literature on agroforestry in Central America follows, to try to get an idea of what practices might be feasible in the Sierra de las Minas region.

## Agroforestry in Central America

Research on agroforestry in Central America is fairly limited, and no specific references to Guatemala could be found. However,

CATIE (Center for Tropical Agricultural Research and Training) has conducted studies in two regions of Costa Rica, and the results from these studies are at least a starting point for investigating the potential for agroforestry in the Sierra de las Minas Reserve.

The research area most similar to the Sierra de Las Minas area is the Acosta- Puriscal Region , situated in the seasonally dry Pacific watershed of Costa Rica. It contains both "moist tropical forest" and "premontane rain forest, " with elevations ranging from 800-1200 meters above sea level. Very little of the region is flat and slopes are moderate (20-30%) to very steep (100%). Rainfall averages are between 2,100-2,500 millimeters per year. Less than 20% of the original forest cover is left. Most of the farms are small: 0-4 ha (48%), 4-10 ha (31%). The rest of the farms are are large and occupy a disproportionate amount of the area , and 65% of it is used for cattle grazing. Soils in the area are classified as Ustic and Typic Tropohumults, Ustic Humitropepts, and Oxic Dystrandepts, and are generally contain a fair amount of clay.

This area has some of the characteristics of the Sierra de las Minas Reserve. Elevation is similar to that of the mid range of the reserve (most likely in the transition zone and buffer zones where agroforestry projects would be feasible). I have no rainfall data on the reserve, but I know that it ranges from very moist rainforest on the north side, to cloud forest at the highest elevations, and down to very dry areas on the south side. Average Rainfall for Guatemala ranges between 1500 and 2000 mm, and the climate of Guatemala is similar to that of most of Central America, with both wet and dry seasons. (Calvert 1985). Data on soils is limited for the reserve,

though an atlas of Guatemala shows that deep clay loams are found in the lowest regions on the north side of the reserve, and soils get progressively more shallow at higher elevations (Insituto Geographico Nacional 1971). It appears that the areas are similar enough that some of the findings from the Acosta -Puriscol area might be transferable to the Sierra de las Minas area. However, more data would be needed on each of the areas to be confident about transferability. (Beer, Borel, and Bonneman 1990; Beer and Heuveldop 1987)

The CATIE research station is located on a 1000 hectare estate at 600-680 meters above sea level, near Turrialba, Costa Rica. Mean annual rainfall is 2600 mm and there is a short dry season lasting one to three months. The soils there have good structure and moderate fertility (Budowski 1983). The elevation and moisture range of this area would be found on the lower parts of the Sierra de las Minas Reserve, but the soils are not likely to be as good, especially since much of the lower parts of the reserve are considered eroded land. Also, the Sierra de las Minas area has much steeper slopes.

## Agroforestry Systems

### Alley Cropping

Alley cropping combines food crops with tree species that may enhance the soil by nitrogen fixation or by producing mulch. In the Acosta-Puriscal Region, studies were conducted on systems

combining the leguminous tree Gliricidia sepium with maize (Zea mays), and beans (Phaseolus vulgaris) (Beer and Heuveldop 1987; Beer et al 1990). In these trials, the application of G. sepium mulch to Bean crops consistently gave favorable results, with yields at least as good as treatments including inorganic N fertilizer. However, the mulch has not been proven to be an effective alternative to inorganic N in the production of maize. It is thought that changing the timing of mulch application will increase the production of maize, but more study on N release and decomposition rates of arboreal leguminous mulches is needed to determine if this is true. Also, more study on the socio-economic limitations of these systems are needed.

Because they were successful (in a biological sense) with bean and G. sepium combinations, and because the Acosta Puriscal Region is somewhat similar to the Sierra de las Minas Area, I would suspect that this system may be applicable to parts of the Biosphere Reserve.

Results of trials at the lower elevation CATIE site were similar, though they found that maize production could be increased with a different tree species Erythrina poeppeieana (Kass 1987).

Pasture and Shade tree combinations

The idea of pasture and shade tree combinations is to provide shade for livestock, and derive other benefits from the trees. The trees can provide fodder and timber, while stabilizing and enhancing (by N fixation) the soil.

Beer and Heuveldop (1987) mention that pasture and shade tree combinations were present in the the Acosta-Puriscal region, but no studies were conducted on them.

Alpizar (1987) conducted trials on pasture and shade tree combinations at the CATIE experiment station. They grew the trees Cordia alliodora and Erythrina poeppigiana with the pasture grass Cynodon plectostachyus (African Star Grass), along with control plots without the trees. They found the highest yields of the grass in the plots with the nitrogen fixing tree species Erythrina poeppigiana. However, no statistical analyses were done, so it is difficult to tell if the differences were real.The plots with Cordia alliodora actually produced less grass than the plots with no trees. Alpizar concluded, however, that the production of the tree for timber was favorable.

These results are inconclusive for the CATIE site, so it would be difficult to predict how well pasture/shade tree combinations would work in the Sierra de las Minas Reserve. However, this doesn't mean that it won't work, and it is possible that pasture/shade tree combinations already exist in the pasture areas in the lower parts of the reserve. Further study is needed.

Taungya Systems

Budowski (1983) and Combe (1981) describe research on Taungya systems, carried out at CATIE. In Taungya systems, seasonal crops are grown with the initial stages of more permanent tree crops. In this way, reforestation can develop better than pure reforestation because the cropping can reduce the weed cover that

would normally compete with the trees. Of course, the other benefit is raising food . The CATIE experiments generally found better tree production in Taungya systems as opposed to systems without food crops. Combinations of various tree species (Cordia alliodora, Ecalyptus deglupta, Gmelina arborea, Terminalia ivorensis) and crops such as maize and beans were tested.

Since the area of CATIE is quiet different , it is difficult to say whether a Taungya system could work on the Sierra de las Minas Biosphere Reserve.

Plantation Crop/Tree Combinations and Multistrata Perrenial Systems

These systems most often combine coffee or cacao with various shade tree species, and sometimes include fruit trees. Coffee tends to do better under shade, and the trees can produce fodder, mulch, food, or timber. Like in other systems, nitrogen fixing trees are often used to enhance the soil. (Budowski 1981). Plantation Crop/Tree systems are also thought to benefit birds, as a greater diversity of species have been found in them than in other agricultural areas (Blockstein 1990).

Beer and Heuveldop (1987) began a study combining coffee with the timber species Cedrela odorata in the Acosta-Puriscal region. They achieved fairly good growth for the tree, but final results are pending.

Fassbender (1987) conducted a study on nutrient cycling in coffee/shade tree systems at CATIE. Two tree species were used:

Cordia alliodora and Erythrina poeppigiana. Fassbender found higher accumulations of N, P, and K in the vegetation and litter of Erythrina poeppigiana/Coffee than in the vegetation and litter of Cordia allidora/Coffee systems. They did not measure the nutrient accumulation of coffee without shade trees.

Budowski (1983) described research on the economics of coffee with shade trees in the area around CATIE. They found that unshaded coffee had slightly higher yields than shaded coffee, but that the economic returns were higher with the shaded coffee because timber could be sold.

Again, it is difficult to draw any conclusions from these studies. However, coffee is grown in the region of the reserve, and it is likely that shade tree systems are used. Further research might help improve the systems and raise the income of farmers in the area.

## Living Fences

Budowski (1987) describes the widespread use of living fences in Central America, where trees are used as posts for barbed wire. The fences keep animals in or out, and the trees can produce fodder, fuel wood, food, shade, or cuttings (which can be sold) to repair fences or produce new ones. The trees can also act as windbreaks, provide habitat for wildlife, and enhance or stabilize the soil. They are utilized from sea level to at least 3000 meters, and in very dry to very wet environments. 92 species of trees have been identified in living fences in Costa Rica -- 20 are proven nitrogen fixers, 41 are

used as firewood, 24 produce edible fruits or flowers, and 21 produce forage for cattle, rabbits of chicken.

The most widespread species used appears to be Gliricidia sepium, a nitrogen fixer. It is very versatile, growing from sea level to 2500 meters, both in dry regions with a 5-8 month dry season and very wet regions. Another versatile species is another nitrogen fixer, Erythrina berteroana. It grows from sea level to 2, 500 meters, but only in fairly moist environments. Two trees well adapted to dry environments are Bursera simaruba and Spondias purpurea.

Because live fences are so common in Central America (though very few studies have been done on them), and because so many species are used and several of them are very versatile, I believe this practice could be utilized in the Sierra de las Minas Biosphere Reserve. It is quite likely that the practice is already in use there. If so, perhaps there are ways that it can be expanded or improved to help meet the needs of the local people.

Biologically speaking, it appears that at least a few of these systems could be utilized in the buffer zone and the transition zone of the reserve. However, very careful social analyses would have to be carried out to determine actual feasibility. Many of the Quekchi Indians do not have land tenure, and have traditionally practiced shifting agriculture (Defensores 1992, Moser 1992). It may be more important to establish tenure before agroforestry assistance is given. The Nature Conservancy and the World Wildlife fund are presently trying to raise money for this purpose. The World Wildlife Fund is also initiating what they call a "human integration project," which

involves agricultural assistance. It seems that agroforestry could be a part of this. Regardless, research trials should be initiated, perhaps coordinated with CATIE and ICRAF. If biosphere reserves are to serve as focal points for conservation, research, and regional development in the tropics, agroforestry should be investigated and utilized whenever possible.

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