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THE ENVIRONMENTAL DEGRADATION OF THE MIOMBO WOODLAND AND THE POTENTIAL OF AGROFORESTRY

H. M. SIBANDA

J. ODRA

GTZ/ARDA
P. O. Box 151
Masvingo, Zimbabwe

ABSTRACT

The Miombo Woodland covers move then 60 percent of each of the four countries studied. This ecozone is characterized by *Brachystegia, Julbernadia,* and *Isoberlinia* tree species. It is dominated by the red tropical soils, namely, the ferralsols, acrisols, and luvisols with decreasing rainfall. The rainfall pattern is unimodal and falls in intense tropical storms which is a potential soil erosion hazard, especially on light to medium textured soils. The current problems in this ecozone are deforestation and overgrazing which have resulted in soil erosion and rangeland degradation in the areas of high population density. Continuous cropping of the inherently poor soils has lowered soil fertility. Agroforestry is a technology that might solve some of the problems of this ecozone. Agroforestry will sustain livestock and crop production, while keeping a check on environmental degradation. The technology can be introduced using selected indigenous species and some exotic species adapted to the environmental conditions.

The rationale behind the study of the environment of such a large area as "the miombo woodland" was the homogeneity of the area falling under the same "agro-ecological zone." Consequently, the environmental problems are similar and the solutions are bound to be similar.

"Miombo" is a "Bantu" name which describes vegetation dominated by *Brachystegia, Julbernadia,* and *Isoberlinia* species. These are deciduous, small to medium size trees (5 to 20 meters) with a single canopy stratum well adapted to water stress and are fire resistant. They are slow growing and are poor in

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coppicing. Most of the tree species are leguminous. Some are nitrogen fixers, while others benefit from a symbiotic association with ectomycorrhizal fungi. Other notable species of the ecozone are the *Acacias, Albizias,* and *Terminalias.* The distribution of this vegetation type is governed by climate, soil, and altitude factors (see Figure 1).

The miombo ecozone is typified by the following characteristics: rainfall, 550-1600 mm; altitude, 300-1800 m; and growing days, 90-270. Although most of Central and Southern Africa falls into this ecozone, only Tanzania, Malawi, Zambia, and Zimbabwe were studied.

SOILS UNDER THE MIOMBO WOODLAND

The FAO/UNESCO soil classification has been adopted for this study. The soils fall into four different classes as can be seen in Figure 2. The Ferralsols cover the wetter parts of the miombo, i.e., subzone 1, 2, and 3, the wetter Zambezian woodland. The dominant type are the orthic ferralsols which are low in fertility except under forests where the organic matter gives them temporary high fertility status. Also found in the ecozone are the rhodic ferralsols described in Table 1.

The acrisols dominant the drier Zambezian miombo woodland, i.e., subzone 3, 4, and 5. The ferric acrisols are the dominant type in the ecozone followed by plinthic acrisols, both are fairly poor in plant nutrients as shown in Table 1.

The luvisols are dominant in the lower rainfall areas of the drier Zambezian woodland and the undifferentiated woodland, i.e., subzone 4, 5, and 6. The ferric and chromic luvisols are the dominant types.

The other soils found in the ecozone are the cambisols and an association of lithosols with luvisols and arenosols which do not totally fall under the miombo woodland.

ENVIRONMENTAL PROBLEMS

Potential Environment Problems

Attention has to be paid to the erosivity of the tropical rains. Since the tropical rains have large rain-drop size and come down in high intensities and quantities (60 mm/hr), they have a high erosive potential. When compared to the temperate rains, the tropical rains have an erosive power that is sixteen times greater [1]. The soils of this ecozone, with the exception of the rhodic ferralsols in Zambia and some ferric luvisols and orthic ferralsols in Malawi, are of medium to coarse texture. The coarser the soils, the higher their erodibility [2]. The slopes in the ecozone range from 0 to 30 percent (Table 1). The steeper and longer the slopes, the greater the chances of erosion. Therefore, a combination of the steep slopes, the high erosive power of the rain and the

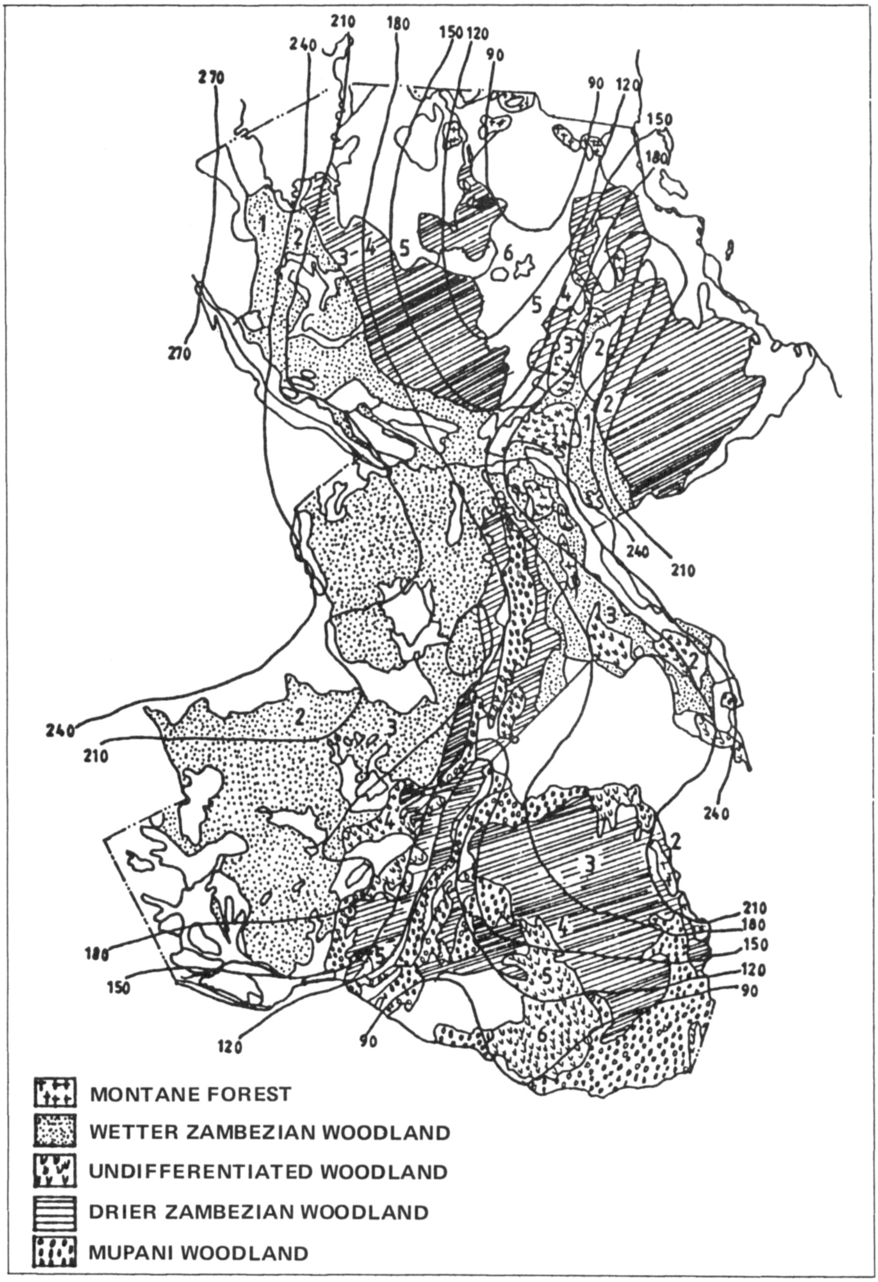


Figure 1. Growing period and vegetation:
Tanzania, Zamba, Malawi, and Zimbabwe.

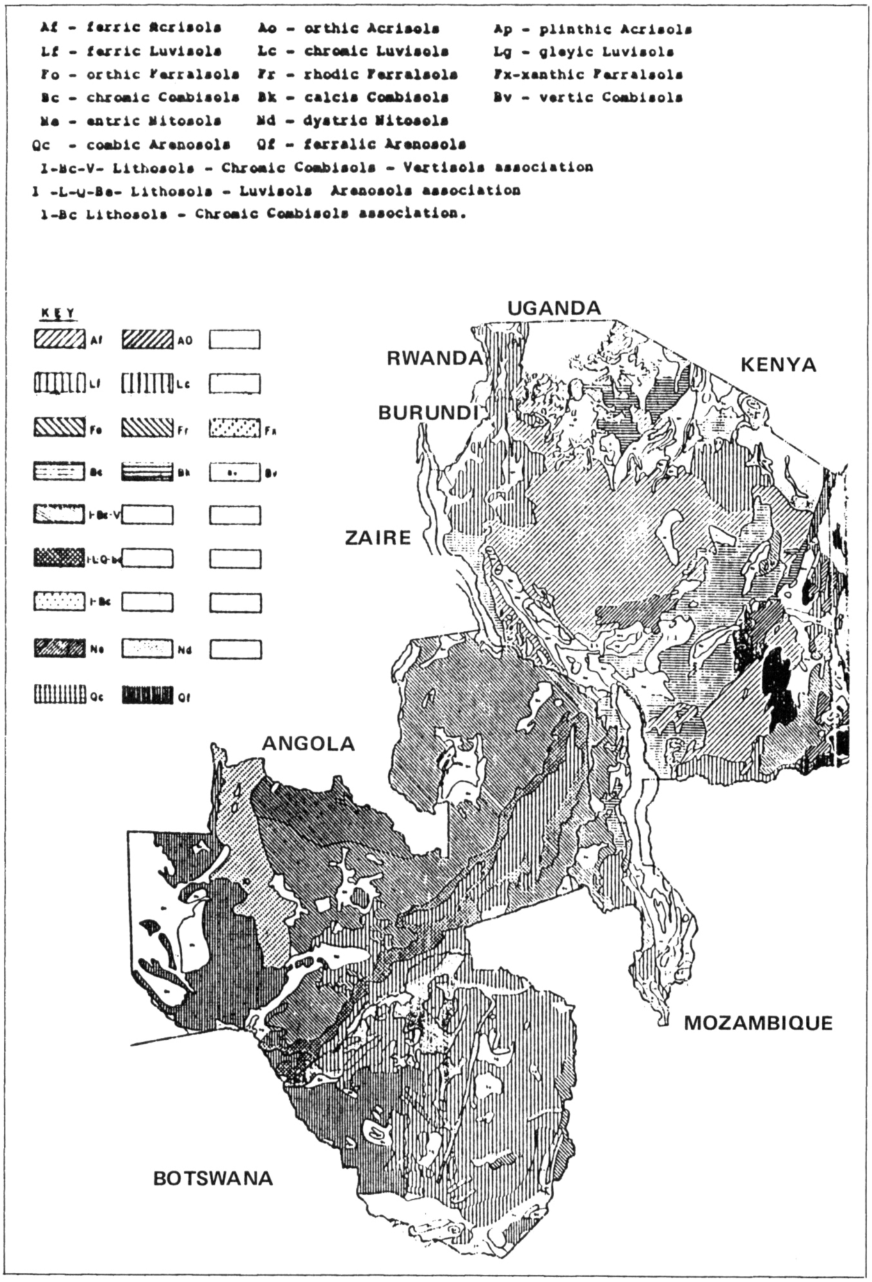


Figure 2. Soil types:
Tanzania, Zambia, Malawi, and Zimbabwe.

Table 1. Some Characteristics of Red Soils of the Miombo Woodland

Soil Class		Associated Soils	Texture	Drainage	Topography	Fertility Status	Soil Suitability	Country	Location with Country Administration Unit
Acrisols	Ferric	Plinthic Acrisols Rhodic, Ferralsols, Arenosol	Coarse and medium	Moderate to well drained	Undulating and rolling in Ruvuma	Low to medium	For cassava, groundnuts, beans and livestock production	Tanzania	Ruvuma, Morogoro, Mbeya Rukwa, Tabora, Shinyang Mwanza
	Orthic	Plinthic Acrisols Ferralic Arenosols	Medium	Moderate to well drained	Undulating to rolling	Low to medium	For cassava, groundnuts, beans and livestock production	Tanzania	Mbeya, Iringa
Luvisols	Ferric	Lithosols	Coarse and medium	Well drained	Undulating	Moderate to low	Groundnuts, tobacco, cotton, livestock	Tanzania	Kigoma, West Tobora
	Ferric	Chromic Luvisols	Fine	Well drained	Undulating	Moderate to low	Groundnuts, tobacco, cotton, livestock	Malawi	Blantyre, Lilongwe Lasungu Adds.
	Ferric	Ferralic Arenosols	Coarse and medium	Well drained	Undulating	Moderate to low	Groundnuts, tobacco, cotton, livestock	Zimbabwe	Matebeleland, South and North Mashonaland, E.C.W. Midlands, Manicaland
	Gleys	Orthic Solonetz	Coarse	Well drained	Undulating	Moderate	Tobacco, maize ranching	Zimbabwe	Mashonaland C, Midlands Matebelsland
	Chromic	Orthic Solonetz	Coarse and medium	Well drained	Undulating	Moderate	Sorghum, cassava	Zimbabwe	Matebeleland, South and North Mashonaland C, Midlands
	Chromic	Orthic Solonetz	Medium and fine	Well drained	Undulating	Moderate	Sorghum, cassava	Zambia	Southern province, Eastern Province, Lusaka Province
Ferralsols	Orthic	Xanthic Ferralsols	Medium and fine	Well drained	Undulating	Low	Cocoa, coffee, oil palm, Intensive agriculture not advisable.	Zambia	Northwestern Province, Central Province, Northern Province, Luapula Province, Southern Province
	Orthic	Xanthic Ferralsols	Medium and fine	Well drained	Rolling to hilly	Low	Extensive ranching	Malawi	Karonga, Mzuzu, Kasungu Lilongwe Adds.
	Xanthic	Orthic and Ferralic Arenosols	Coarse and medium	Well drained	Undulating to rolling	Low	Rubber, cocoa, coffee, oil palm and grazing	Zambia	West of Central Province, Western Province, Northwestern
	Rhodic	Orthic Ferralsols	Fine	Well drained	Undulating	Low to moderate	Cassava, banana, coffee, tea, maize	Zambia	Northwestern Province, Copperbelt Province

erodibility of the soils are a recipe for erosion unless something is done about the situation.

Vegetation cover intercepts raindrops reducing the impact in the soil consequently reducing the erosivity of the rainfall. Its presence increases infiltration and moisture storage due to the mulching effect. The lack of vegetation which is prevalent in the ecozone due to overgrazing and deforestation results in increased surface runoff which leads to sheet erosion and siltation of streams and dams.

The soils of this ecozone are inherently low in fertility as shown in Table 1. The high temperature and relatively high rainfall produce a favorable environment for microorganisms which in turn decompose the parent rock and organic matter at high rates. The nutrients are leached by the heavy rains leaving the soils in a low fertility status. The soils are characterized by acidic pH's of 4 to 4.5 for ferralsols, 4.5 to 5.5 for acrisols, and 5 to 6 for luvisols which are not very conducive to plant growth. At these acidic pH's, ferric oxide (red color) and aluminium oxide are dominant minerals with a high phosphate fixation capacity. The human population pressure cannot be divorced from the physical aspects of this environment. With increased population density, the traditional shifting cultivators are forced into a continuous cropping situation without any fertility management aspect. Also, the types of crops that are grown (maize, tobacco, cotton, sorghum, millet) are high nutrient demanding without returning anything to the soil. These crops do not provide a good ground cover especially at the early stages of growth. Also, with over 80 percent of the energy for cooking coming from wood fuel and with present population pressure, deforestation is inevitable. Also, with the tradition of keeping livestock as part of the household and especially the Sukumas of Tanzania and Ndebele of Zimbabwe and Tongas of Zambia who keep livestock as a measure of wealth, overgrazing becomes inevitable. This devegetation of the environment by humans and livestock makes the area more susceptible to erosion.

Present Status of the Soils and Problems

The information on the present status of the environment with respect to problems and potentials for agroforestry is presented on a country basis. Similarities on a zonal basis will be highlighted.

Tanzania – About 50 percent of the ecozone is sparsely populated in terms of humans and livestock due to low rainfall, infertile soils, and tsetse infestation. The only areas of high human and livestock population are Mwanza and Shinyanga, northern Tabora, western Kigoma, southern Mbeya and Rukwa, and western Ruvuma and Morogoro regions. Due to pressure in these areas there is continuous cropping without any nutrient inputs in terms of manure and fertilizers as crop residues and cow dung are used as fuel for cooking. There is widespread deforestation for fuel wood and for tobacco curing in southern

Tabora region. There is also widespread overgrazing leading to severe soil erosion as can be seen in Figure 3, in Mbeya, Rukwa, Kigoma, and western Shinyanga and Tabora. Deforestation has also been observed to be a result of bush clearing by the Sukuma (the tree hating tribe) to eliminate tsetse fly since they are a cattle keeping tribe [3].

Zimbabwe – Over 75 percent of the rural population lives in the communal lands which fall into Natural Region IV and V dominated by granite outcrops, steep slopes, lithosols, sodic soils, and vertisols [5]. Whereas the good agricultural lands Natural Regions I to III was divided into large commercial farms owned exclusively by whites during the colonial era and are largely still in the same hands [4]. The communal farmer practices subsistence production on 4 ha which has been cropped continuously for over forty years with very little being done to replenish soil nutrients. Therefore there is severe soil fertility decline signified by the low maize (stapple food) yield of 1.4 tons/ha compared to 8 tons/ha for the large commercial farms [6]. Due to the communal grazing system which has resulted in lack of management of the grazing areas, overgrazing is the order of the day in the communal areas. Deforestation is another feature of the communal areas since 90 percent of energy for cooking comes from fuel wood as shown in Figure 3. A forecast by Katerere shows that by the year 2002, Zimbabwe will have a fuel deficit of seven million tons if today's rate of deforestation continues [7]. Presently, fuel wood shortage is already being experienced by some communal areas as signified by the use of crop residues and cow dung as a fuel [7].

Malawi – Malawi is a hilly country and receives heavy erosive rainfall. High human and livestock populations densities are found in the south. The land pressure in the south has made the shifting cultivation a non-viable system, therefore continuous cropping has led to soil fertility decline especially on ferralsols with pHs between 4 and 4.5. Due to the communal land ownership, overgrazing has exposed the ground on steep slopes for the rains to carry away the loose top soil. Since 90 percent of the country's household energy needs are dependent on fuel wood, deforestation is continuing at such a rate that by the year 2000 only two of twenty-four districts will still be self-sufficient in fuel wood [8].

Zambia – Due to the sparse population in most of the country, shifting cultivation (chitemene) is practiced. Although soil fertility decline is not yet a problem under this system, the consequences of a shorter fallow period are being felt. In the south of the country and along the railway line, soil fertility decline is already a problem under permanent cropping especially the further lowering of the acidic pHs of the ferralsols (Figure 3). In the south, central, and western provinces where cattle are kept as a symbol of wealth, serious overgrazing has led to soil erosion especially early in the rain season. Soil erosion has also been reported in the cleared patches for shifting cultivation [9].

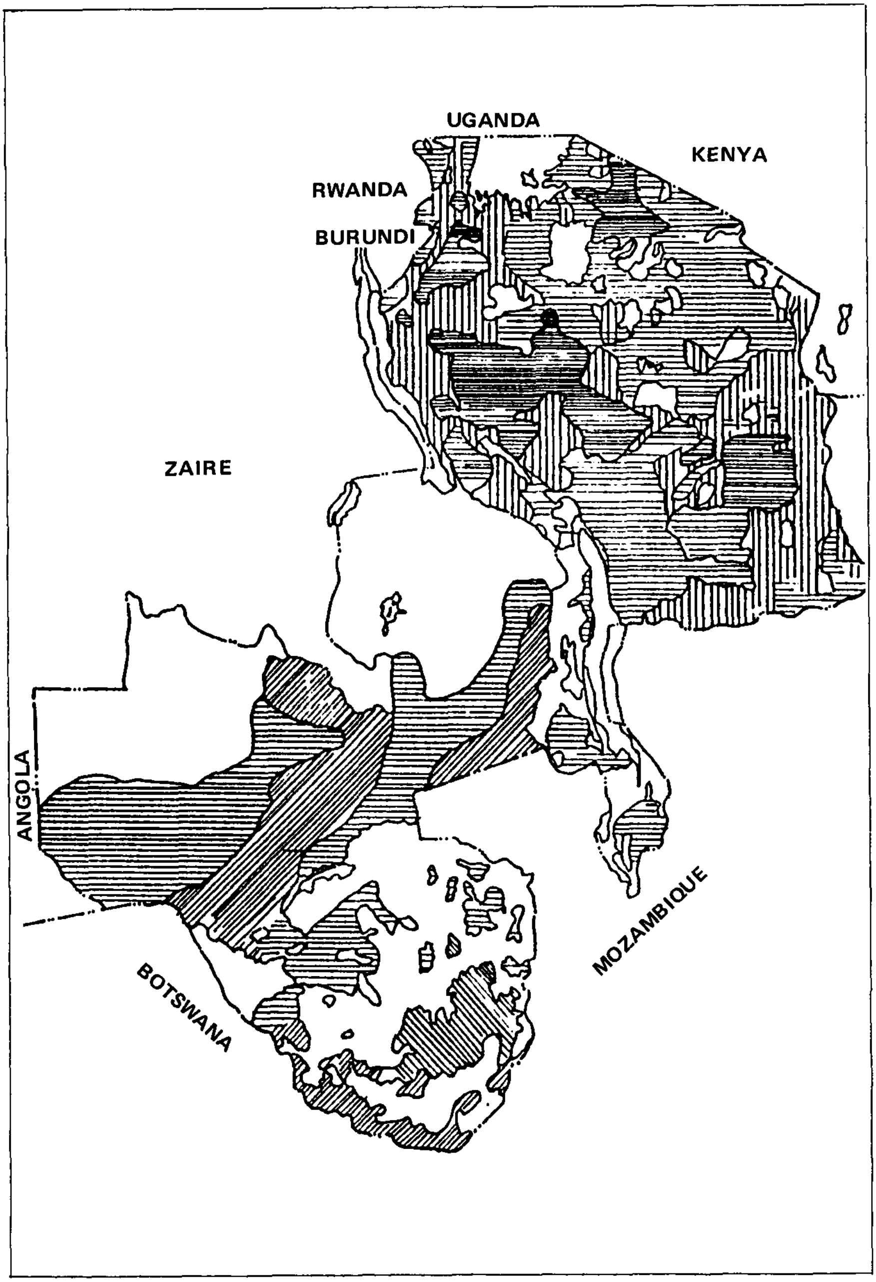


Figure 3. Soil erosion:
Tanzania, Zambia, Malawi, and Zimbabwe.

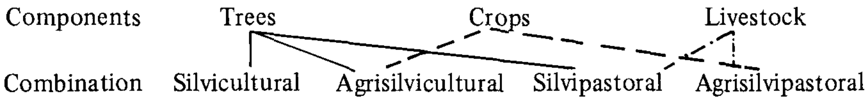
Deforestation is taking place at the rate of 9000 km^2 under the shifting cultivation system; it is also evident in the tobacco growing areas and around the towns of Lusaka, Kabwe, and Livingstone, where a radii of 120 km have been cleared of trees for fuel wood.

In all the four countries, soil erosion, fertility decline, overgrazing, and deforestation are common problems although they are at different levels in each country. The national government's concern over environmental protection indicates the awareness of these problems. Also, the outcry of national governments about population control shows the awareness to the fact that land is a finite resource. Any increase in population, will increase the demand for food, housing, and clothing from the same land. The land users are aware of environmental degradation but they neither have the capital nor the technology to stop it. A sound resource management principle that will enhance the productivity of the soil and prevent degradation is required. The land users need a sustainable system of production so as to pass on the land to their children in a reasonable state. Since the farmers have demonstrated the soil rejuvenation by trees in the shifting cultivation system, what is the affordable system they can use for sustainable production? Can agroforestry be the system or technology to at least halt further environmental degradation while allowing farmers to harvest their food and cash crops.

AGROFORESTRY AS A POTENTIAL SYSTEM FOR THIS ECOZONE

Definition

Agroforestry refers to multiple land use systems and practices in which woody components are deliberately grown on the same land management unit as crops and/or animals, either on some form of spartial arrangement or in time sequence. The system should permit significant economic and ecological interactions between the woody and nonwoody components (ICRAF's definition) [10]. These are practices that have been carried out by small holders in American, African, and Asian tropics for many years without being acknowledged as beneficial systems or practices. Therefore very little is known scientifically about them and very little research has been done, if any. These are systems like the "taungya system" in Asia where landless farmers are allowed to produce crops in the early years of a forest plantation. In so doing, they weed the plantation and the crops benefit from the falling litter of the trees. Another example from the miombo woodland itself is the deliberate leaving of the "miracle tree," i.e., *Acacia albida* in Malawi within the crop land to provide fertility to the growing crops. Agroforestry can be divided into four different systems as shown on page 218.



Where:

Silvicultural: trees are grown alone either for fruits and timber or fuel wood.

Agrisilvicultural: trees and crops are combined in space as in alley cropping or in time as in improved fallows.

Silvipastoral: integration of trees for timber, etc., and pastures for livestock or growing browsable trees in the rangeland or as living fences.

Agrisilvipastoral: combination of food crops with productive trees for timber with leaves that are browsable by animals or with pasture grasses underneath the trees which can be cut to feed animals.

Though agroforestry is a feasible solution for the ecozone, it is not *the* system that will solve all problems of this ecozone. It is just one system that can be applied to solve some of the problems. Although much can be done to improve soil fertility or provide fodder for livestock, agroforestry's advantage is that it has a land use system approach. Prior to conclusions being drawn about agroforestry suiting any particular situation, it would be necessary to analyze a production system as a whole to know all its weak and strong points. For example, advising farmers to use chemical fertilizers when they cannot afford them or advising them to plant trees when they cannot spare any land would not help. We will therefore analyze what agroforestry can do for various situations and at the same time, look into the bonuses of the prescribed agroforestry system.

Having analyzed the situation about the soils in this ecozone, the two outstanding problems are soil erosion, mainly by water, and soil fertility decline. In areas where they both occur, they are due to human and livestock population pressures which have led to deforestation, overgrazing, and continuous cropping without any fallow period for soil rejuvenation or addition of nutrients in terms of chemical fertilizers. An agroforestry approach that will effectively address these problems will have to look at increasing fodder for livestock, maintaining ground cover and reducing deforestation which will result in reduced surface runoff on grazing lands. Supplementing animal fodder during the dry season would prevent the animals from devegatating the rangeland.

Since trees have deeper rooting systems than grasses, they are able to utilize ground water when the water table has receded during the dry season. As a result, they provide a better alternative fodder during the dry season. Tree species with a fodder potential and a soil conservation role achieved by maintaining good ground cover at the beginning of the rains may be the most desirable. This may prevent animals from stripping the rangeland clear during the dry season and provide alternative feed at the onset of the rains. As a bonus, such trees would provide poles, timber, and fuel wood, resulting in the slowing down of the rate of deforestation. Therefore, the selection of "Multi-Purpose Trees" (MPTs) that will provide at least the two basic requirements is very important, since the land is scarce and the land users are increasing. Also, some of these trees could be planted in the "waste" lands around the homestead or as hedgerows. Examples include *Sesbania bispinosa, Gliricidia sepium, Parkia biglobosa, Albizia schimperiana.*

Soil fertility decline in the ecozone is observed to be a result of pressure on land, i.e., permanent cultivation having replaced shifting cultivation. The land users have demonstrated the importance of trees in maintaining soil fertility by the shifting cultivation system. They should be encouraged to plant fast growing trees on grass strips and among crops in a particular pattern so that nutrient recycling is maintained by leaf fall. The trees can also be grown on edges of cropland or in small wood lots and then branches can be lopped and spread on most fields, temporarily providing soil cover and later releasing nutrients back to the soil as they decompose. Trees are also capable of bringing back the deeply leached nutrients to the surface through their deep root system. These trees should be fast growing, easy to manage and have good coppicing properties. Examples include *Prosopis juliflora, Prosopis africana, Leucaena leucocephala, Tamarindus indica, Psidium guavaja, Acacia albida.* Some of these trees are leguminous nitrogen-fixers.

Acacia albida is a unique case. It shades its leaves during the rainy season when crops are growing and new leaves only grow during the dry season. Like the other MPTs, *Acacia albida* can be utilized as fodder, timber, and fuel wood as useful bonuses in the ecozone since the miombo woodland is rapidly disappearing.

There are other important facts to consider when looking at the agroforestry potential of this ecozone. Some local miombo tree species are potential agroforestry species like the *Acacia, Albizia, Ziziphus, Ficus,* and *Uapaca kirkiana* of which some are leguminous nitrogen-fixers and in addition produce fruits, fodder, and timber. It should be emphasized that these agroforestry species are just as good as the exotic species if not better, since they are already adapted to the ecozone. They can meet most of the requirements desired in the ecozone.

Lastly, the social and economic aspects of this technology have to be considered. Questions like "are trees acceptable within the crop land?" need to be clearly verified before the technology can be recommended. It should also be taken into account whether the agroforestry system designed would be a more viable system economically and ecolpgically than the existing system because if it is not, there would not be any point introducing it.

As indicated initially, agroforestry is not a new practice. Therefore, before introducing the system, it will be interesting to look around and see the existing agroforestry practices in the ecozone and analyze them first, and see their weak and strong points. Examples of such existing practices are the leaving of *Acacia albida* trees in crop lands of Malawi, the shifting cultivation in Zambia, the lopping of certain tree species for animal fodder in almost all the four countries. After analyzing the systems, one would try to improve them to cover some other requirements needed to conserve the fragile miombo woodland environment.

Maybe for the miombo woodland, agroforestry could be the technology the people can afford and manage with the available resources. It might be the technology that will bring about sustainability in the production systems of the ecozone. This is a technology worthwhile thinking about "a technology of production with sustainability."

REFERENCES

1. N. Hudson, *Soil Conservation Publication,* B. T. Batsford Limited, London, 1971.
2. G. J. Bouyoucos, The Clay Ratio as a Criterion of Susceptibility of Soils to Erosion, *Journal of American Society of Agronomy, 27,* pp. 738-741, 1935.
3. Devres Agricultural Research Resource Assessment, 1984: Volume II—Tanzania, Zimbabwe, Zambia, Malawi, SADCC Report, 1984.
4. X. Whitlow, Deforestation in Zimbabwe—Some Problems and Prospects: A Supplement to Zambia, *Geographical Proceedings of Zimbabwe,* 1980.
5. ______, Deforestation—Some Global and National Perspectives, *Geographical Proceedings of Zimbabwe, 12,* 1979.
6. E. M. Shumba, Crop Production under Marginal Communal Areas Environments, *Zimbabwe Science News, 19,* 1985.
7. Y. Katerere, Fuelwood Consumption Patterns and Supply in Rural Zimbabwe, *Working Paper 23,* Zimbabwe Energy Accounting Projects, 1984.
8. *Reports on the State of Environment in Malawi, Zambia, Zimbabwe, Tanzania,* SASREG, Mbabane, Swaziland, October 16-18, 1985.
9. IUCN Report, *Towards Sustainable Development: A National Conservation Strategy for Zambia,* First Report, 1984.
10. B. C. Ludngren and J. B. Raintree, *Sustain Agroforestry,* ICRAF Reprint No. 3, 1983.

Direct reprint requests to:

Dr. H. M. Sibanda
ARDA-PPU/GTZ, P. O. Box 151
Masvingo, Zimbabwe, Africa