
TECHNICAL PAPER # 57

UNDERSTANDING AGROFORESTRY TECHNIQUES

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Published By
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Understanding Agroforestry Techniques
ISBN: 0-86619-276-X

PREFACE

This paper is one of a series published by Volunteers in Technical Assistance to provide an introduction to specific state-of-the-art technologies of interest to people in developing countries.
The papers are intended to be used as guidelines to help people choose thechnologies that are suitable to their situations. They are not intended to provide construction or implementation details. People are urged to contact VITA or similar organizations for further information and technical assistance if they find that a particular technology seems to meet their needs.

The papers in the series were written, reviewed, and illustrated almost entirely by VITA Volunteer technical experts on a purely voluntary basis. Some 500 volunteers were involved in the production of the first 100 titles issued, contributing approximately 5,000 hours of their time.
VITA Staff included Suzanne Brooks handling typesetting and layout and Margaret Crouch as editor and project manager.

Co-author Fred Weber, a pioneer in the community forestry concepts presented here, has advised

projects for over 20 years. He wrote the original edition of the VITA publication Reforestation in Arid Lands based on a training manual he prepared for Peace Corps volunteers in Niger. Carol Stoney collaborated with Mr. Weber on the revisions for the new edition of Reforestation, which is the basis for the techniques in this technical paper. Frederick J. Holman, a landscape architect, provided the illustrations in this paper, which are taken from Reforestation.

VITA is a private, nonprofit organization that supports people working on technical problems in developing countries. VITA offers information and assistance aimed at helping individuals and groups to select and implement technologies appropriate to their situations. VITA maintains an international Inquiry Service, a specialized documentation center, and a computerized roster of volunteer technical consultants; manages long-term field projects; and publishes a variety of technical manuals and papers.

UNDERSTANDING AGROFORESTRY TECHNIQUES
by VITA Volunteers Fred Weber and Carol Stoney

I. INTRODUCTION

Agroforestry refers to the integration of trees and shrubs as essential elements

**of agricultural
and other land use systems, with the idea of improving the fertility and productivity of the soil.
In this concept, trees and shrubs can be deliberately managed (that is, established, tended, protected,
harvested, etc.) and considered as one of the resource elements used by people or their livestock,
even though the trees may appear to be randomly dispersed in the landscape. Trees and shrubs,
then, need not be forests, woodlots, orchards, or other discrete stands especially set aside for
a single purpose or product. Rather, they can be planted wherever people have not allocated
the space to some other use. In many situations this makes much more sense than setting aside
specific areas of usable farm land for woodlots--where the most acute problem is lack of food,
for example, not lack of wood. Certain tree species may provide food (fruit, leaves, edible seeds,
etc.) not only for people but also for livestock, particularly during seasons when food supplies
from other sources are low.**

**In addition to producing wood for fuel, construction, implements, tools, and art objects, other
important and locally appreciated by-products of agroforestry include fiber for mats, baskets,
and rope, or plant materials for medicines, dyes, tannin, cosmetics, and glue. These raw materials**

were easily obtainable a few generations ago when extensive woodlands still existed throughout dry regions. Today they are scarce because much of the "useless brush" has been converted to farm fields or plantations of rapid growth species, the use of which is usually limited to only a single product.

Agroforestry or soil conservation techniques, often combined, can help to stabilize cultivation on a given piece of land. Certain of these methods help prevent or reverse environmental damage in areas where fallow cropping is no longer practical. Adding trees and shrubs as permanent features in the landscape in the form of field trees, border and alignment plantings, windbreaks, and live fencing can protect the soil against erosion and improve nutrient cycling. Proper maintenance of trees in agroforestry or soil conservation systems may allow permanent cultivation of farm fields that previously could only be fallow cropped.

Many of the techniques described in this paper are based on farming systems that have evolved to allow long-term sustainable production systems to take the place of shifting cultivation. Most can be used by anyone who wishes to make better use of trees and shrubs to restore or improve their land. The techniques have been drawn largely from VITA's publication

**Reforestation in
Arid Lands by Fred Weber and Carol Stoney.**

II. AGROFORESTRY TECHNIQUES

**A wide assortment of different agroforestry techniques is being used today. Many are based
on traditional practices that have been carried on for generations. Others are relatively new,
"invented" by technicians working with local farmers or pastoralists and still being adapted to
varying site conditions. The methods described here provide a practical guide for use in the
field, rather than extensive coverage of background information, theory, and reference sources.
As a practical measure they have been divided into two categories: on-farm, which includes
those most directly related to agricultural operations, and off-farm, which includes non-agriculture
techniques.**

ON-FARM TECHNIQUES

**Trees can be integrated with crops in a number of ways. They may be dispersed randomly across
a field, planted in careful rows between rows of other plants, or planted as separate stands for
orchards or woodlots. Trees may also be used to mark borders or as live fencing.**

Dispersed Trees

Intensive interaction between crops and trees occurs when they are grown together. The classic farm/park landscape that covers large parts of the Sahel is a perfect example of a traditional agroforestry arrangement where trees dispersed in farm fields form an integral part of a cropping system. Different species are found in these dispersed, park-like stands, depending on site conditions. The best known are Acacia albida, Butyrospermum parkii, Parkia biglobosa, and Borassus aethiopum.

In traditional systems these trees regenerate naturally, and so they are more or less homogeneously distributed across fields in random patterns. Where they have been regenerated through human efforts they are planted in lines (normally 10m x 10m). Regular spacing is particularly important if mechanized cultivation, such as animal traction, is practiced. The main feature of this approach is that the trees are more or less uniformly dispersed either in a natural, irregular pattern or more systematically in a grid pattern.

Some problems do arise. The seedlings are difficult to protect from grazing when they are young (up to five years). Brush fences or woven baskets can be placed around

**individual trees, but
this is expensive. Birds are also attracted to the trees, especially when they are established near
rivers and lakes. The birds can cause problems for farmers if they eat crops and seed.**

**Efforts to introduce Acacia albida in farm fields in the Sahel have been particularly successful,
however, because this species drops its leaves during the rainy season and does not leaf out
again until well into the dry season. Cereal crops can be grown under the leafless trees during
the rainy season. The crowns of almost all other tree species compete with light-demanding
crops for space, thus the areas shaded by the trees cannot be used for crop production. Even
small trees can create enough shade during the rainy season to take a significant part of a farmer's
land-holding out of production.**

<FIGURE>

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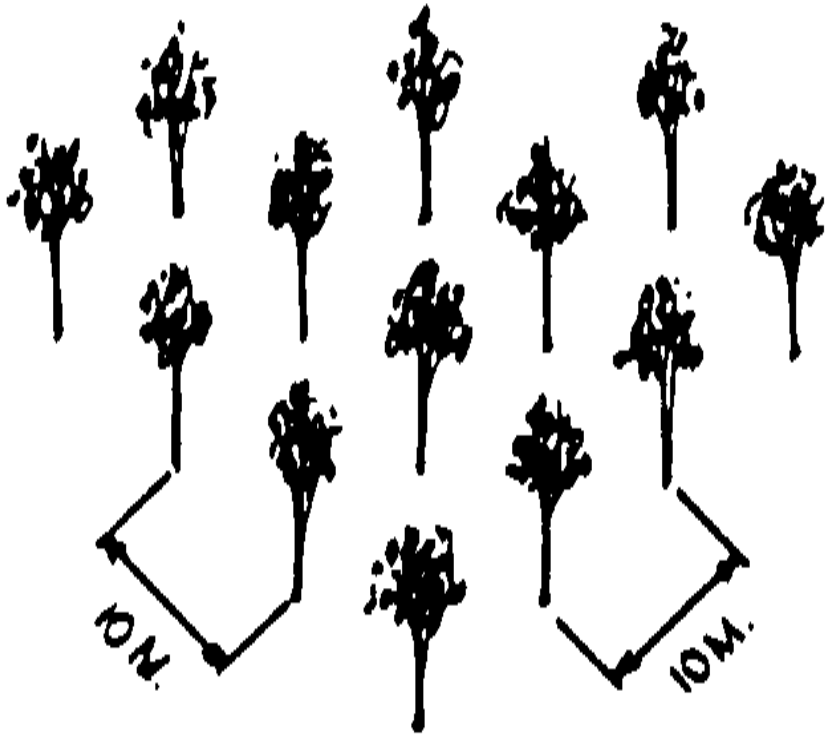

Dispersed Trees

Alley Cropping

Small trees or shrubs, pruned frequently to prevent them from producing too much shade, are grown in relatively compact rows (between 2 and 4m, never more than 6m apart). Crops are grown in the space--the "alley"--between the rows of trees. This method was developed in more humid areas of the tropics, and it is being tried in drier regions of

Africa, Asia, and Latin America. The International Institute of Tropical Agriculture (IITA) has been experimenting with alley cropping in Nigeria for a number of years, as has the Centro Agronomico Tropical de Investigation y Ensenanza (CATIE) in Turrialba, Costa Rica, in Central America. Most research is focused on obtaining the right species combination, but the question as to which crops respond best to which tree species also varies according to site conditions.

Leguminous trees, such as Calliandria calothrysus, Leucaena leucocephala, Mimosa species, Prosopis cineraria, and Acacias, are often used in alley cropping schemes because their nitrogen-fixing ability enriches the soil. Such diverse crops as corn, millet, cowpeas, yams, and manioc can be grown in the alleys. The trees/shrubs are pruned as often as five times per year. The clippings are laid down as a mulch around both trees and crops, gradually decomposing and becoming incorporated into the soil as organic matter. The shade and mulch from the tree rows also reduce weed growth. Yields of some crops are higher between the mulched rows than in comparable fields that are not being alley cropped. The IITA found that yields from maize were three times greater after four years of mulching with Leucaena leucocephala clippings (IITA,

1986).

<FIGURE>

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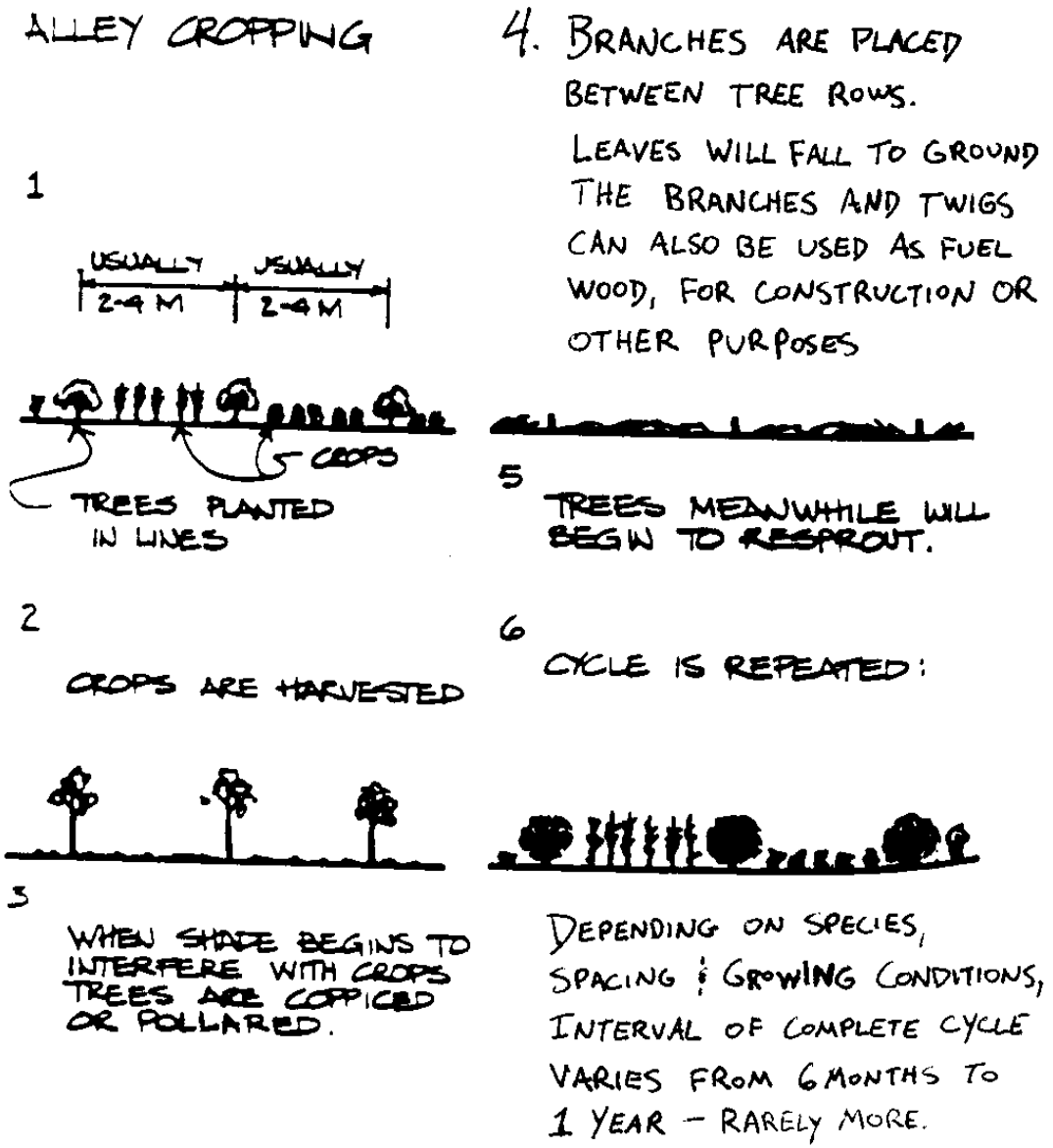

Farmers may want to use the pruned branches for poles or firewood. The clippings can also

be used as fodder for livestock. If the leaves and branches are not used to mulch the crops, alley cropping may not have the effect of increasing crop yields, but it will still be an effective technique for controlling soil erosion, increasing the availability of tree products, and maintaining agricultural sustainability.

In addition to the increased complexity of matching compatible crop and tree species to specific site conditions, several other problems may limit the widespread adoption of alley cropping. A major consideration of farmers who are considering various intercropping schemes is the amount of arable land that the trees will take up. Farmers tend to favor methods that will take as little land out of crop production as possible. Alley cropping requires fairly close placement of tree rows, which can substantially reduce the amount of land left for the crop rows. Where land scarcity is a problem, therefore, alley cropping is probably not the best method to use.

Alley cropping also requires fairly strict adherence to planting and pruning schedules in order for the technique to give good results. If the trees are not cut back at regular intervals, they will create too much shade for the intercropped plants. For light sensitive crops like corn, too

much shade over a period of just a few days can interrupt flowering and fruiting processes.
Other crops simply do not thrive in excess shade. Trained extension personnel are needed to
work closely with farmers on crop and tree species selection and on setting up planting and
pruning schedules.

Line Plantations

Another alternating row arrangement involves planting larger trees at a wider spacing (7 to 10m)
with crops planted between the rows. In this system, species that provide fuelwood, and timber,
Grevillea robusta, or fruit trees like avocado and citrus, are often used. As much as 60 percent
of the species composition of the line plantations may be shrubs. Other possibilities such as
Markhamia platycalyx, Inga vera, Trema orientalis, and Maesopsis eminii are being studied on
trial sites, where they serve as shade trees for coffee plantations. Several species of Acacia or
Cacao and Gmelina arborea can also contribute to honey production. The species mix should
include trees that provide different products as well as nitrogen fixing plants.

<FIGURE>

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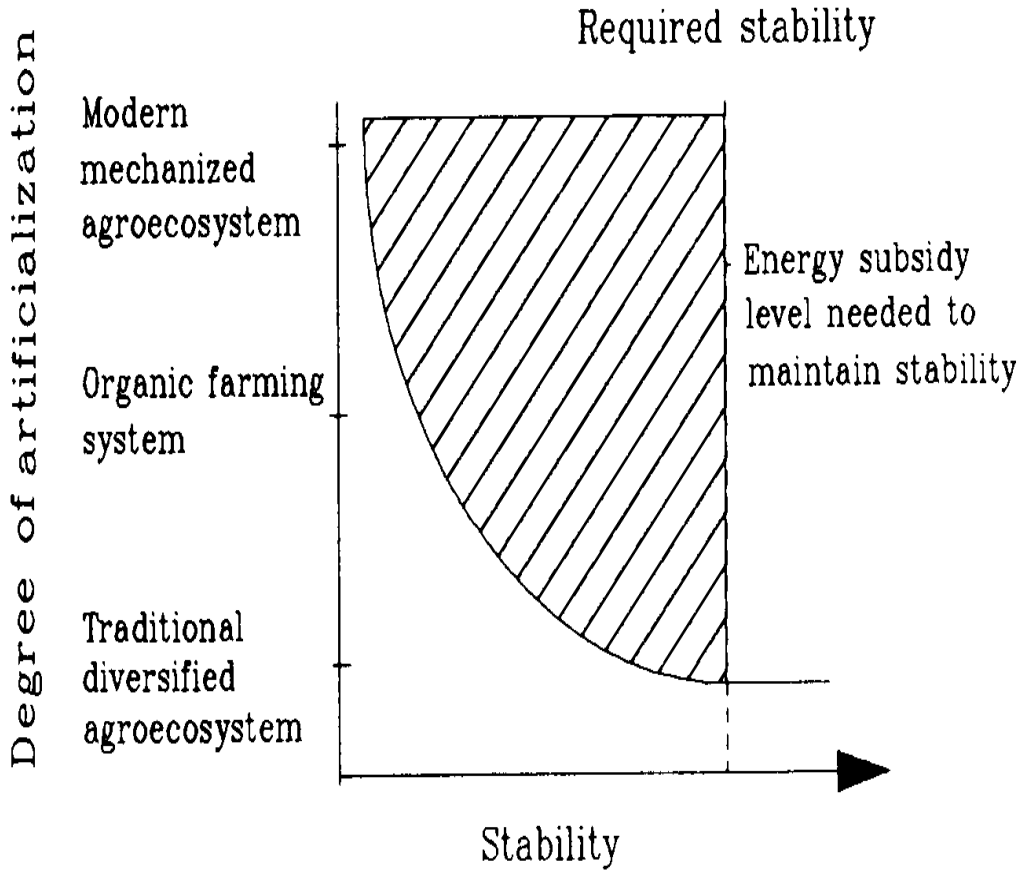
MODIFICATION OF THE NATURAL SYSTEM RELATED TO ENERGY SUBSIDY AND STABILITY



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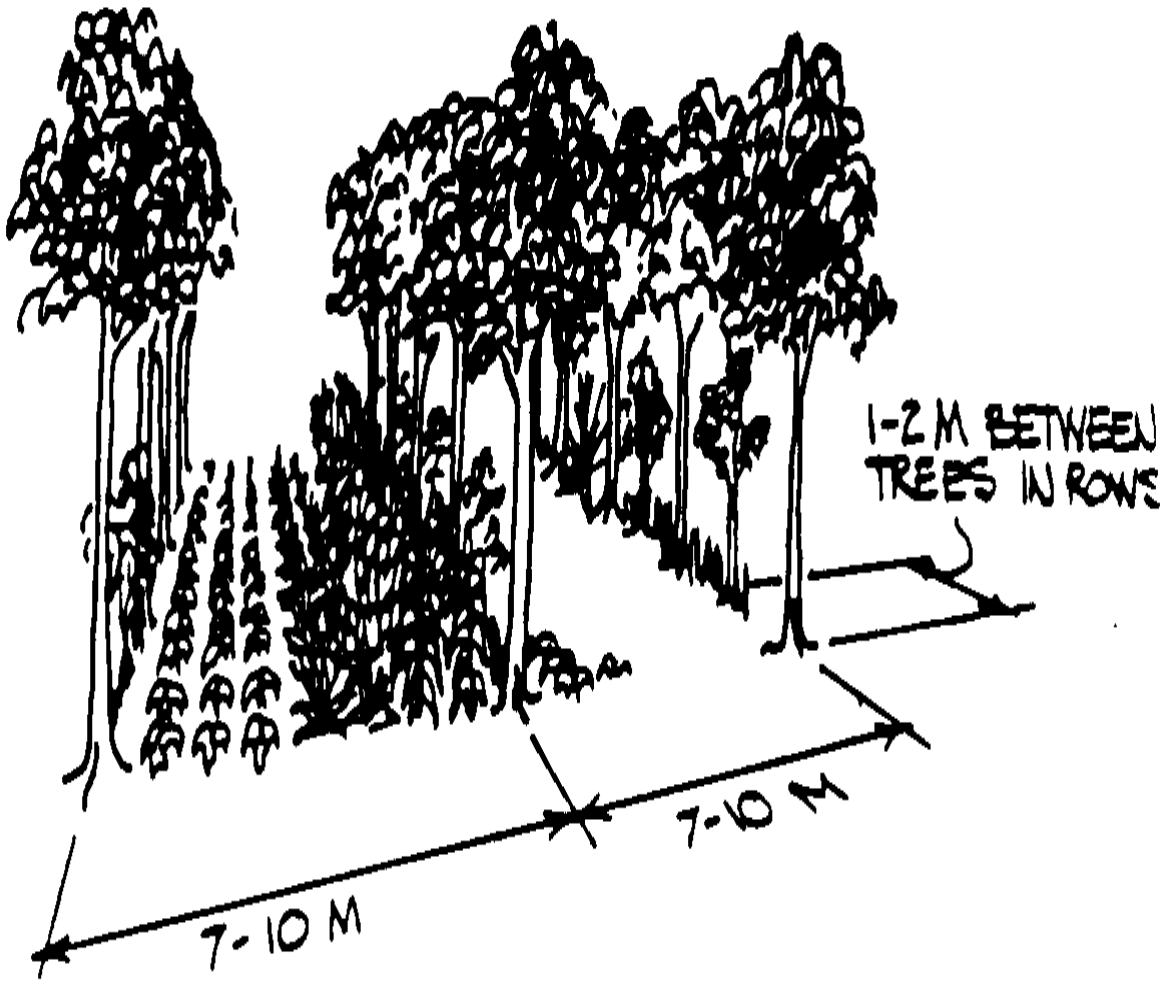

Line Plantation Spacing

Borderline Trees

**Borderlines consist of trees, shrubs, and grasses established to delineate individual farm fields.
They serve as property markers while they provide wood and other products for various purposes.
They do not occupy too much space, nor do they shade large areas of the fields. Because the
tree rows are not actually in the fields, they do not interfere with regular farming operations.
As in line plantations, wood and other products can be harvested from the trees.**

**The promotion of additional species for borderline plantation has potential, if species selection
takes into consideration local preferences. Protection of young trees is necessary unless the species
being used are unpalatable to livestock. Issues of land and tree tenure should be carefully researched
and discussed with a community before this technique is tried. If the trees are planted on a
borderline between two farmers' property, to whom do the trees and the harvesting rights belong?
There may be several alternative approaches to resolve this question, but all parties involved
should agree in advance as to how the situation will be handled.**

<FIGURE>

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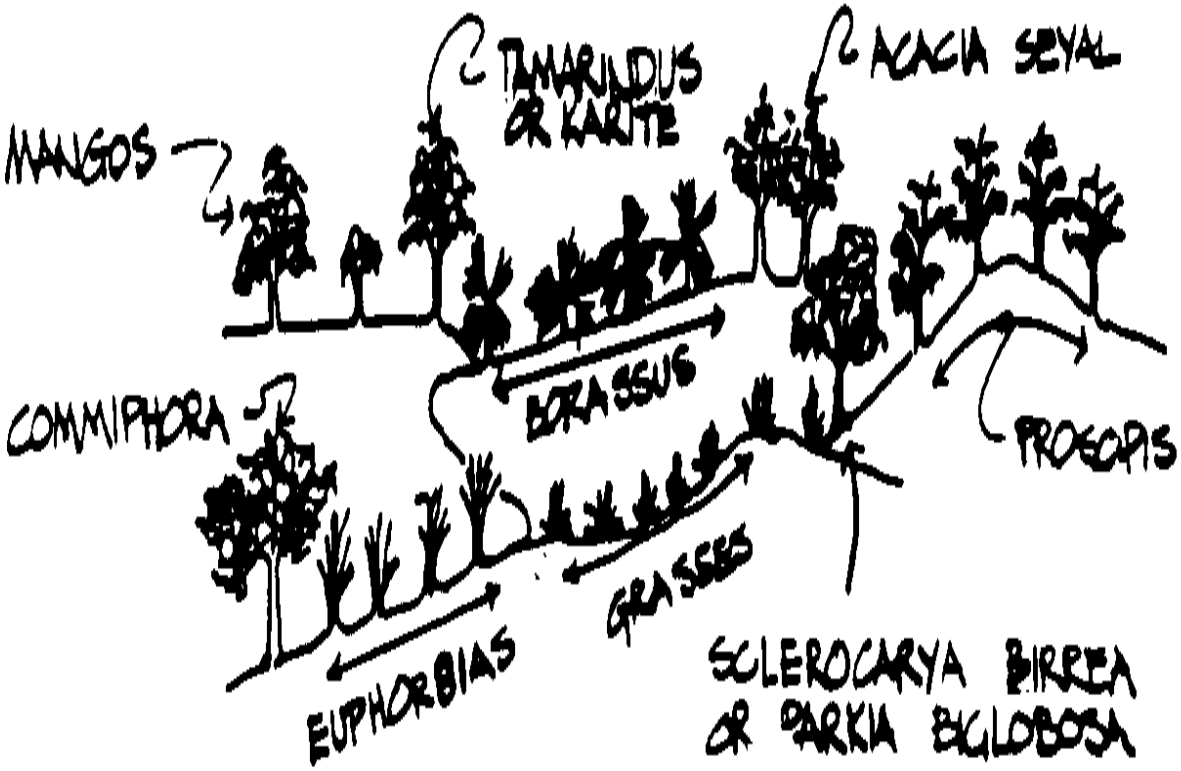

Borderline Trees

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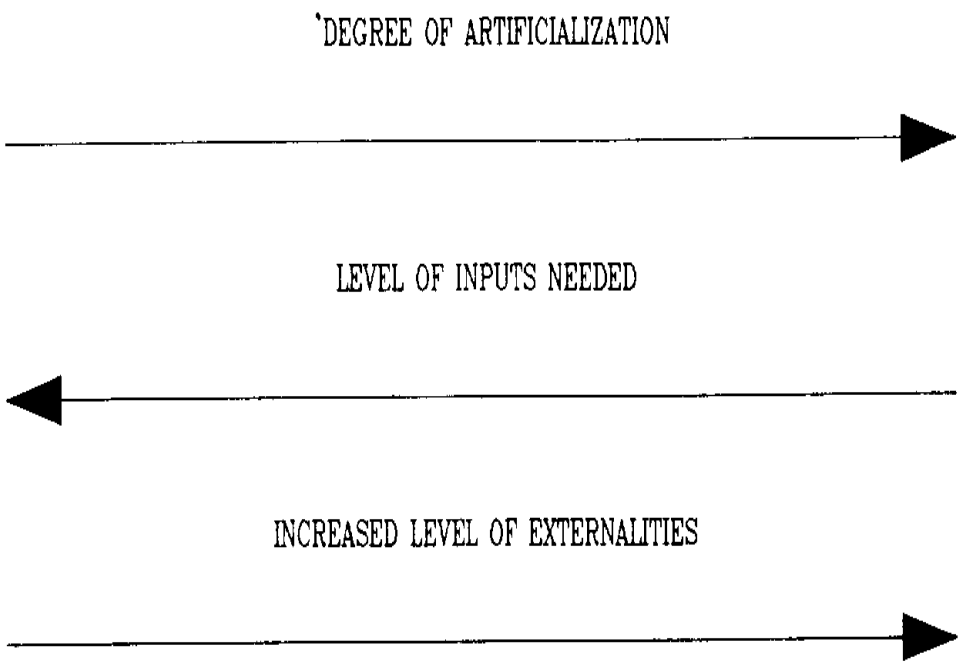
EFFECTS OF MODIFYING THE NATURAL ECOSYSTEM

Agroforestry systems	Traditional polycultures	Plantation systems	Commercial
(perennial crop based)	(seasonal crop)	(perennial crops usually in monoculture)	annual crops (sugar cane, cotton, etc.)



Live Fencing

Live fencing consists of dense hedges or thickets usually planted around a garden or farm field to protect it from free ranging livestock. They are also planted around family compounds and other buildings. This technique differs from borderline plantations in that shrubbier species are used, the shrubs or trees are tightly spaced (0.5-1m), and they are intensively pruned to maintain a compact, dense barrier. This is a very important alternative to traditional fences that are constructed and annually repaired using interwoven thorny branches.

A number of species have shown that they adapt well to use as live fences. Members of the Euphorbia family are especially good because animals will not eat them (people too must be careful--when Euphorbias are cut, the milky sap can cause severe irritation if it touches the skin). A number of Acacia and Prosopis species as well as Leucaena, Gliricidia sepium, and Cajanus cajun, are also useful for this purpose.

<FIGURE>

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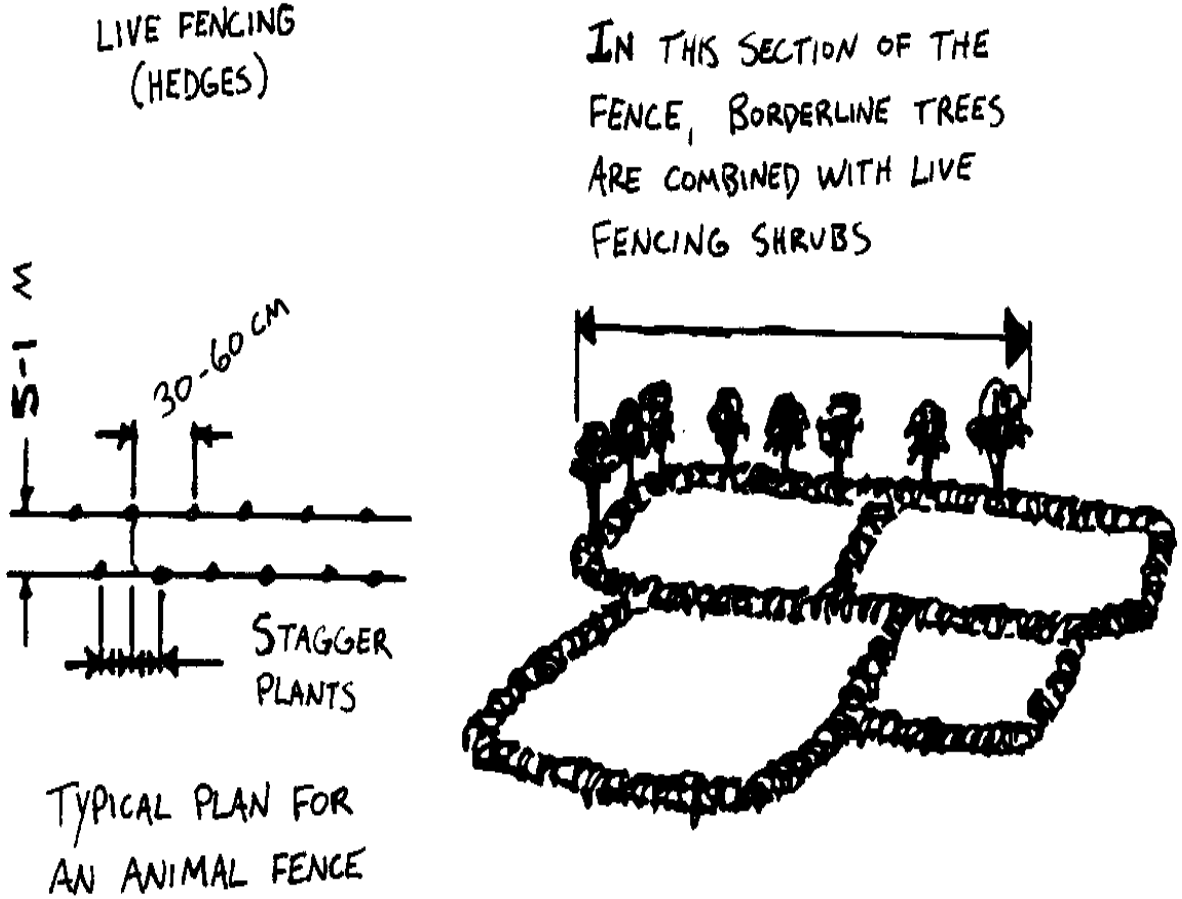

Spacing for Live Fencing

Frequently, the main function of a hedge is to keep animals out. If this is the case, plants must

be spaced tightly and kept well pruned. Select species that are:

*** Thorny**
*** Easily coppiced (sprout back)**
*** Relatively unpalatable**
*** Fast growing**

No one species will meet all these requirements. Trade-offs are inevitable although a mixture
of species may provide the most protection. Final choice depends much on specific site conditions.
If protection from animals is not a primary concern, the spacing between plants can be wider.
Hedges can have many other advantages and functions besides keeping out animals:

*** Demarcation of property boundaries**
*** Protection against wind**
*** Addition of organic matter from leaf litter**
*** Fruit and forage, when combined with borderline trees**
*** Privacy**

As garden fences, or wherever irrigation is possible, trees for a live fence can be started by
direct seeding. The seeds should be planted in furrows or in small pockets placed at intervals
along the fence row.

<FIGURE>

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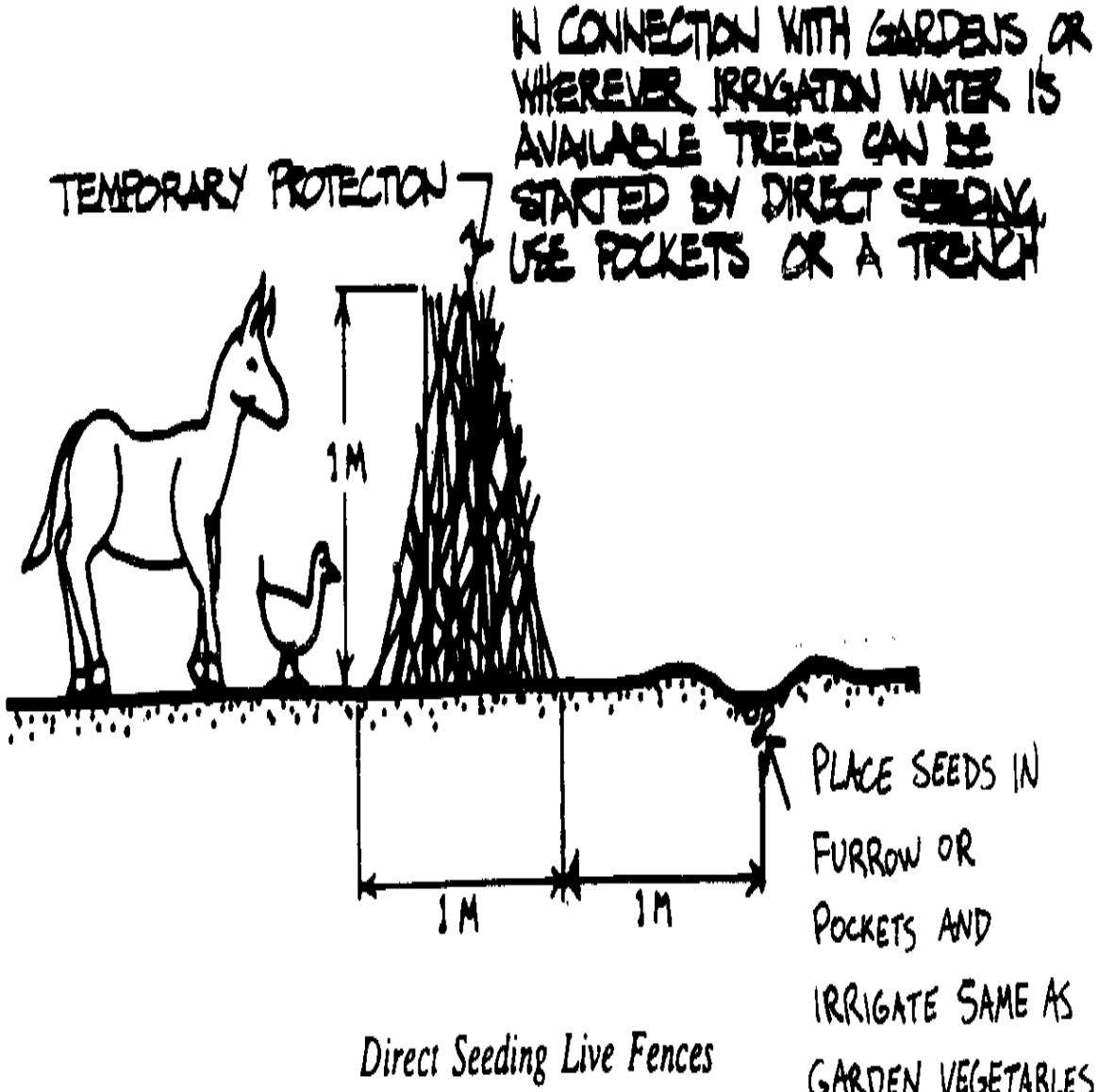

Direct Seeding Live Fences

Live fences can also be established from cuttings, especially from some species such as Gliricidia sepium, members of the Euphorbia and Commiphora genera, and some perennial legumes. Freshly cut branches from these species are likely to make root and sprout if they are planted at the beginning of the rains. These species are therefore, particularly useful for establishing live fences.

Normally, one would not wait until the beginning of the rainy season to build fences, but this might be done when using post materials that may take root. Care should be taken not to damage the bark or wood when attaching wire for the fence.

<FIGURE>

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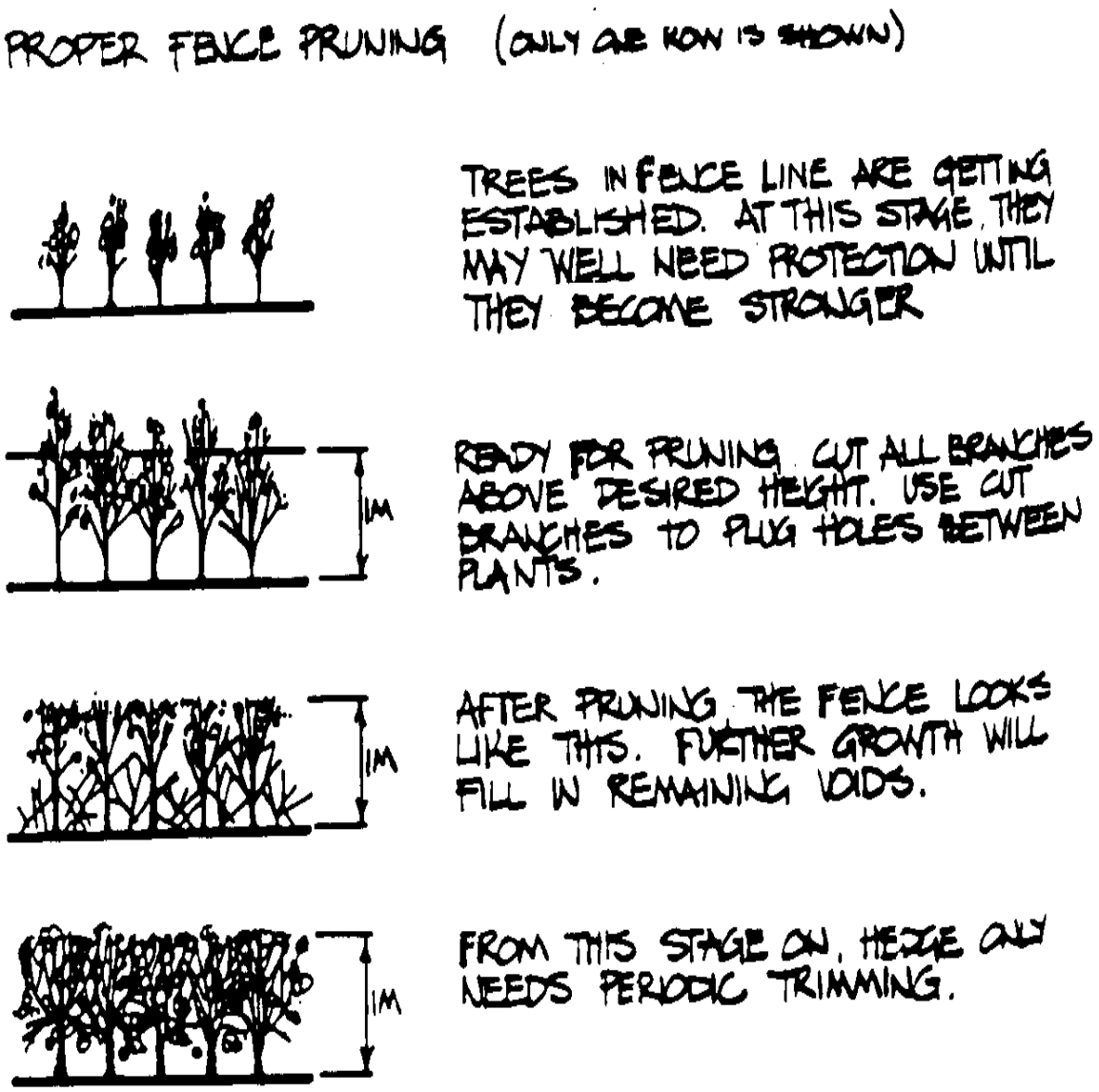

Establishment of Live Fencing from Cuttings

OFF-FARM TECHNIQUES

In most rural areas as well as in towns and urban areas, there are unused spaces along roads and water courses, and around houses and public buildings. While they may traverse agricultural land, these open spaces are not used for agricultural production. Trees planted in these spaces can enhance the environment by providing erosion control and shelter from the sun and wind for both people and animals.

Road and Trail Alignment

A long-standing tradition in many tropical areas is to line roads with trees, mainly for shade, but also for wood and other tree products. This practice can be extended to include foot paths and trails. Certain species such as Albizia lebbek and Syzygium cumini are common street trees in India, Sesbania grandiflora is often found in the Philippines, and Prosopis alba in South America.

A frequently made mistake has been to plant trees too close to the road. On major roadways, enough room must be left for two vehicles to pass with additional space on the roadside for vehicles to pull over in an emergency. A space of less than seven meters between tree rows creates traffic hazards. Additional width is needed around curves, because the

trees reduce the
distance ahead that drivers can see.

<FIGURE>

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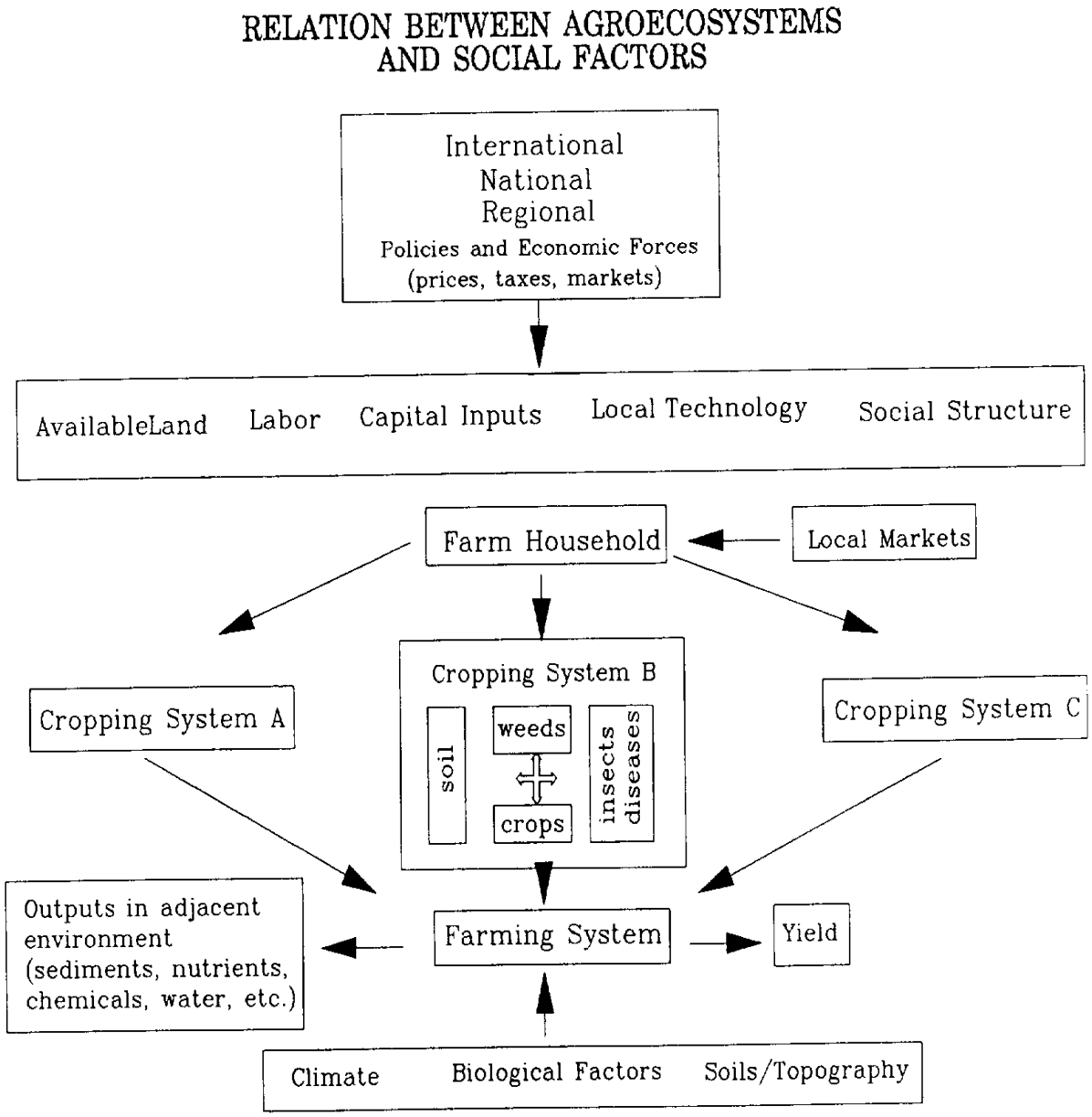

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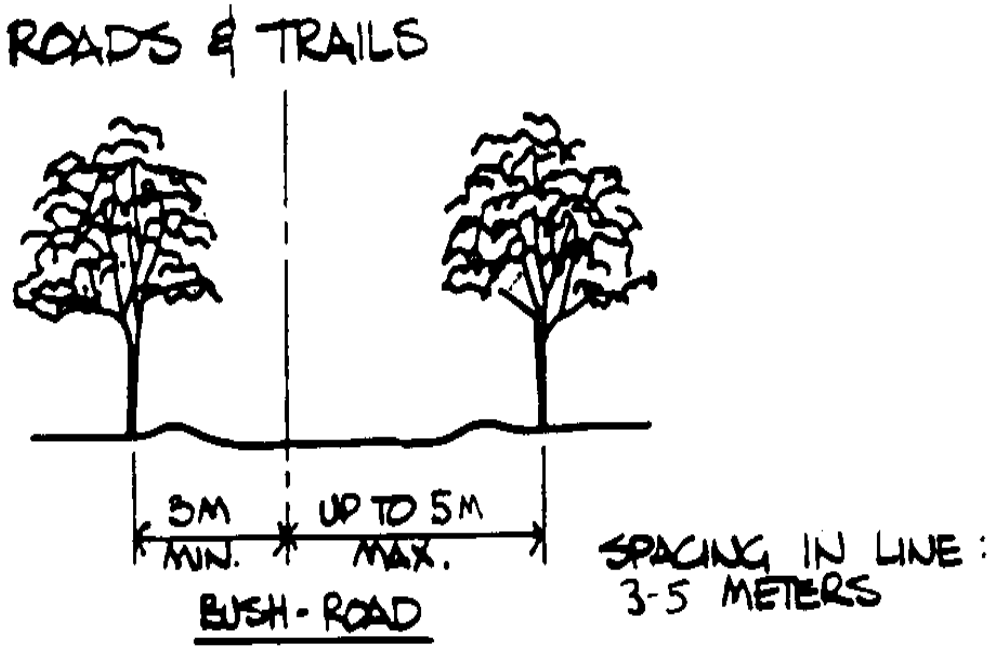

Trees are also established along livestock and bicycle trails and footpaths, sometimes in combination

**with live fencing or rock walls to control access to adjacent fields. Shade and fruit trees are
favored for footpaths.**

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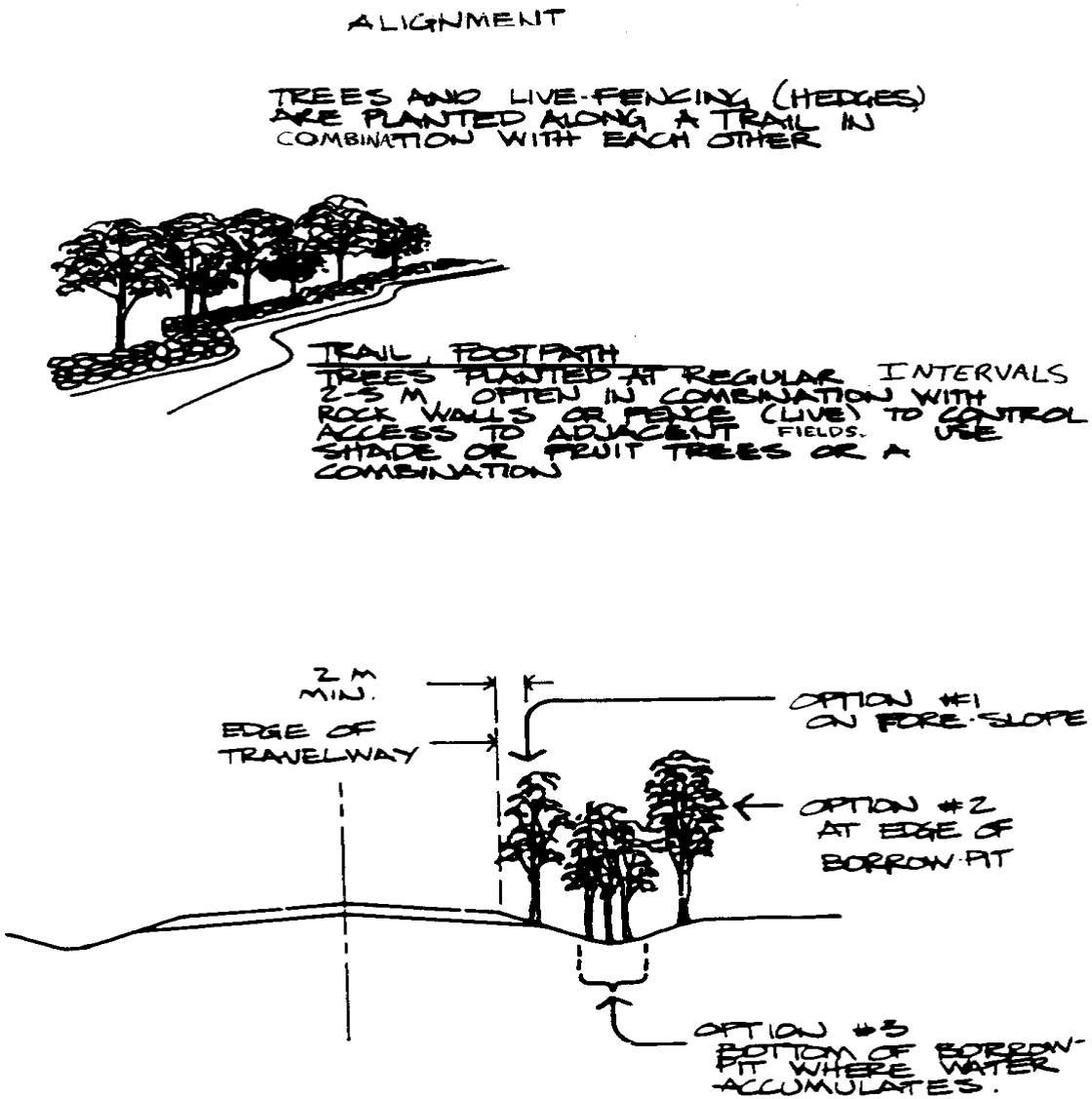

Placement of Trees Along Roads and Paths

Water Course Alignment

**The banks of streams are frequently cleared for cultivation of cereal crops or irrigated gardens.
They are extremely susceptible to erosion once the natural vegetation has been removed. These
areas can be protected by restoring tree and shrub cover along the stream banks. Water course
alignments also create good habitats for wildlife.**

**Trees and shrubs can be established around water sources in much the same way as alignment
plantings along roads. Rivers, ponds, or drainage canals in irrigation schemes provide excellent
growing conditions for trees. Fruit trees (mangos, citrus) should be given special consideration
because of their value as food sources. Dry river beds (wadis) provide a suitable site for species
such as Tamarix, Anogeissus leiocarpus, Prosopis spp., or other more drought-resistant varieties**

<FIGURE>

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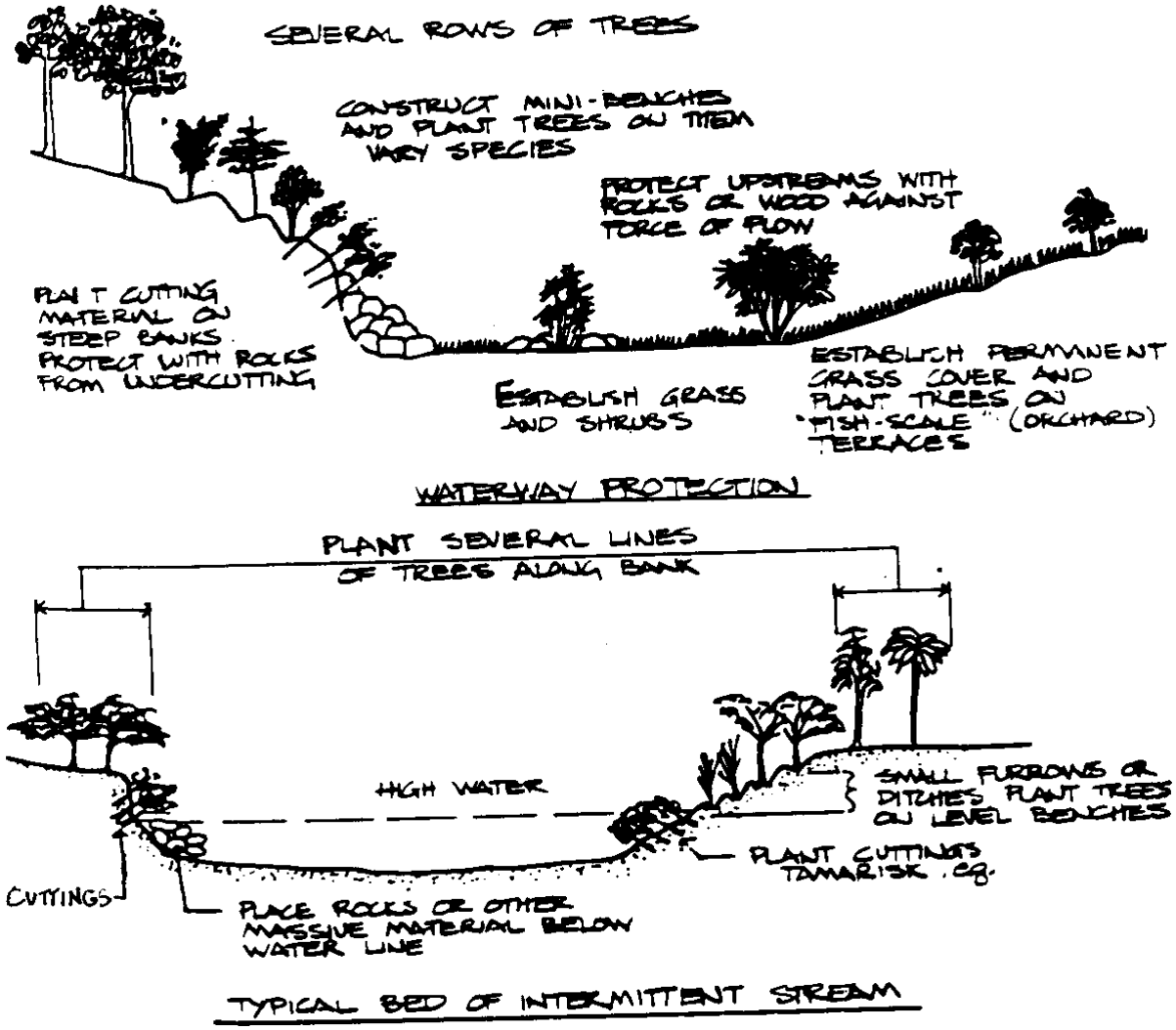

Water Course Alignment

<FIGURE>

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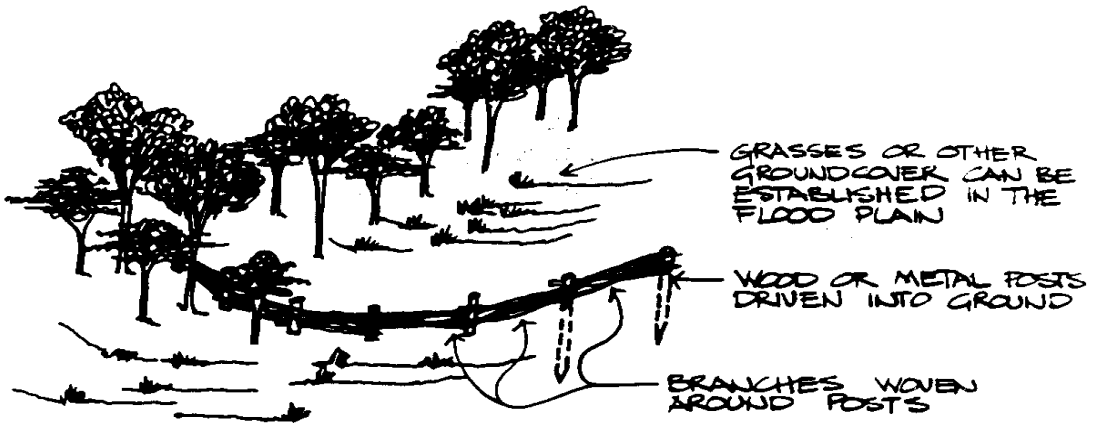
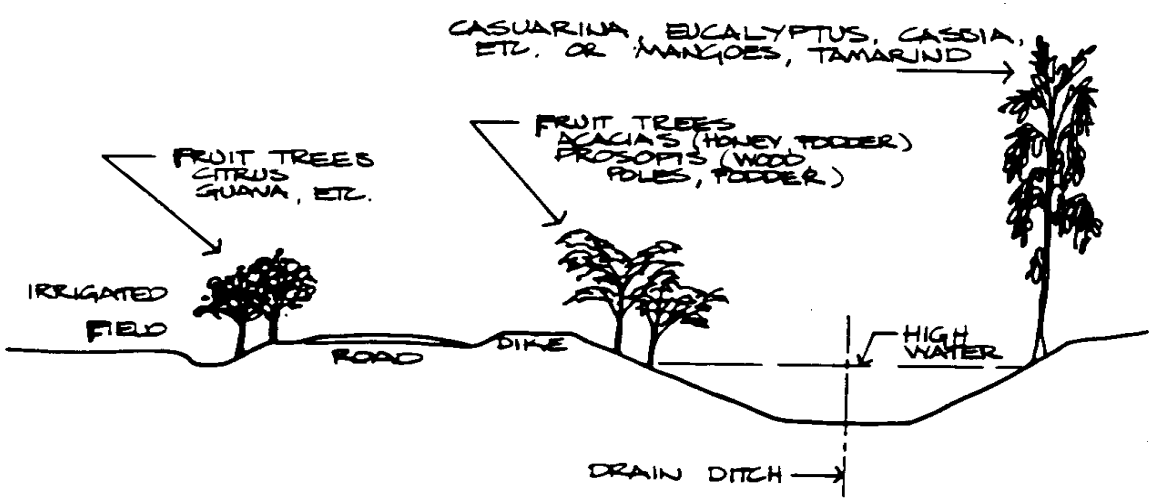


TYPICAL LOCATION FOR ESTABLISHING TREES OR SHRUBS ALONG WATERWAYS



TREES ALONG DRAINAGE STRUCTURE

Shade Trees

Shade trees planted in public places around government buildings, schools, market places, churches, and mosques serve an important function. These are areas where people congregate during the day, and shade is an essential part of the environment. These are also places where trees can be established and maintained quite easily by local people themselves with minimal assistance from outside.

Most of the street and road trees mentioned above are excellent shade trees. Others are Pithecellobium dulce, Azadirachta indica (neem), and Grevilla robusta.

Trees planted in public places usually need individual tree fences to protect them until their branches are out of reach of free-ranging animals. Even after they are no longer threatened by livestock, good local cooperation is needed to keep people from over-harvesting the trees. For example, the twigs of the neem tree are very popular in Africa for toothpicks. A seemingly harmless practice like breaking off an occasional twig can, however, stunt the growth of young neems if the stems are continuously stripped by passers-by.

Although farmers generally try to restrict the amount of shade in areas where

**crops are grown,
shade trees are used to protect livestock from intense heat during the day.
Shade trees are particularly
necessary wherever animals are corraled or fenced in, and around watering spots.**

<FIGURE>

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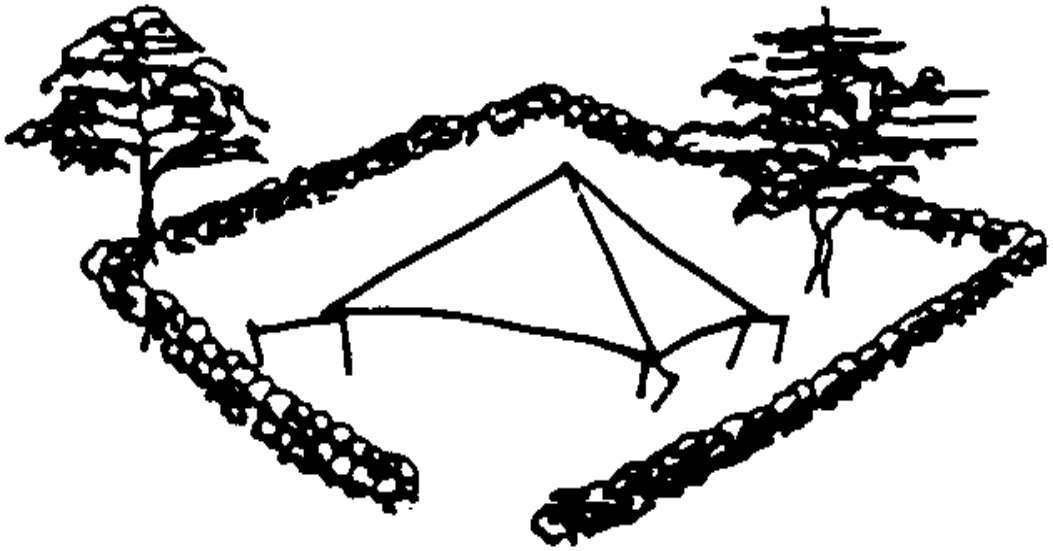

INDIVIDUAL PERMANENT ENCAMPMENT (PASTORALIST AREAS)

EUPHORBIA HEDGE: AROUND A COMPOUND IN MAURITANIA WITH INDIVIDUAL TREES INSIDE

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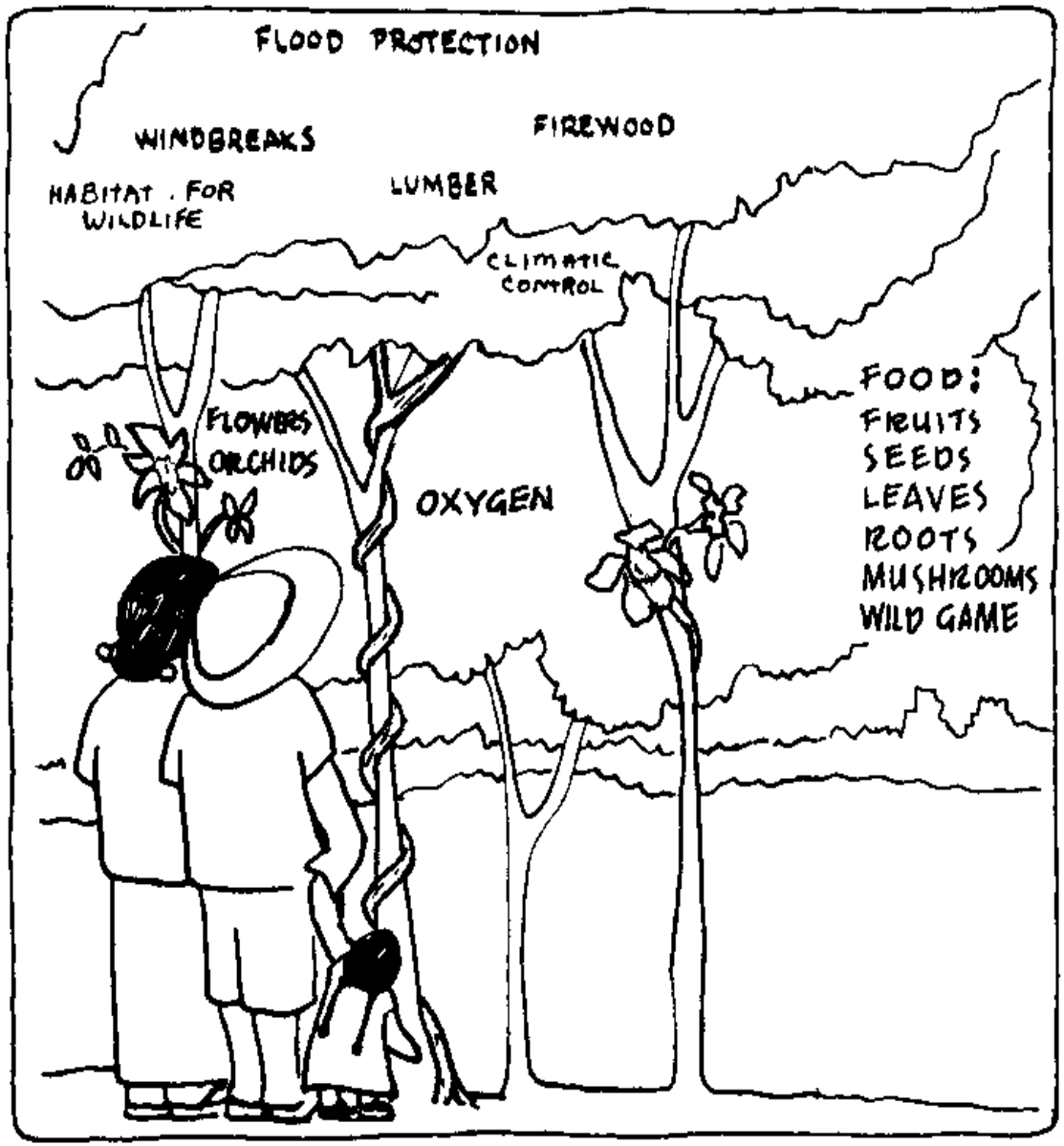
FLOOD PROTECTION
WINDBREAKS
FIREWOOD
HABITAT . FOR WILDLIFE
LUMBER
CLIMATIC CONTROL
FOOD:
FRUITS
SEEDS
LEAVES
ROOTS
MUSHROOMS
WILD GAME
FLOWERS ORCHIDS
OXYGEN

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Polytechnic Institute, Department of Sociology.**

INFORMATION SOURCES

**The following organizations work in arid forestry, range management, or agriculture, and can be
contacted for information on specific problems:**

Research Organizations

**Centro Agronomico Tropical de Investigacion y Ensenanza (CATIE)
Department de Recurses Naturale
Turrialba, Costa Rica**

**Centre Technique Forestier Tropical (CTFT)
45 Bis Avenue de la Belle Gabrielle
94 Nogent Sur Marne
France**

**Consultative Group on International Agricultural Research (CGIAR)
1818 H Street**

Washington, DC 20433 USA

Environment and Policy Institute
East-West Center
1777 East-West Road
Honolulu, HI 96848 USA

International Crops Research Insitute for the Semi-Arid Tropics
Patancheru P.O.
Andhra Pradesh 502 324
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National Academy of Sciences
Board on Science and Technology for International Development (BOSTID)
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Washington, DC 20418

Nitrogen Fixation by Tropical Agricultural Legumes (NifTal) Project
P.O. Box 0
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