REFORESTATION IN THE REPUBLIC OF SENEGAL:
FRAMEWORK, DESCRIPTION AND ANALYSIS

by

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ACRONYMS

BNE	Budget National d'Equipement
CCCE	Caisse Centrale de Coopération Economique
CIDA (ACDI)	Canadian International Development Agency
CILSS	Comité Inter-états de Lutte contre la Sécheresse dans le Sahel
CNRF	Centre National de Recherches Forestières
CNUCED	Conférence des Nations Unies sur le Commerce et le Développement
CTFT	Centre Technique Forestier Tropical
DGEF	Direction Générale des Eaux et Forêts
FAC	Fonds d'Aide et Coopération
FAO	Food and Agriculture Organization (United Nations)
FCFA	Franc Communauté Financière Africaine Exchange Rates (FCFA per US $1): 1983 (381), 1982 (329), 1981 (272), 1980 (211), 1979 (213), 1978 (213), 1977 (246), 1976 (239), 1975 (214), 1974 (240), 1973 (223); Source: International Financial Statistics (IMF).
FED	Fonds Européen de Développement
GATT	General Agreement on Tariffs and Trade
IDRC (CRDI)	International Development Research Centre
ISRA	Institut Sénégalais de Recherches Agricoles
OMVS	Organisation pour la Mise en Valeur du Fleuve Sénégal
ORSTOM	Office de la Recherche Scientifique et Technique Outre-Mer
PARCE	Projet Aménagement et Reboisement du Centre-Est
PARFOB	Projet Autonome de Reboisement de la Forêt de Bandia
PASA	Projet Anacardier Sénégalo-Allemand
PRECOBA	Projet de Reboisements Communautaire dans le Bassin Arachidier

SAED	Société d'Aménagement et d'Exploitation des Terres du Delta
SCET	Société Centrale pour l'Equipement du Territoire International
SERST	Secrétariat d'Etat à la Recherche Scientifique et Technique
SODEFITEX	Société pour le Développement des Fibres Textiles
SODENAS	Société de Décorticage des Noix d'Anacardiers
SODESP	Société de Développement de l'Elevage dans la zone Sylvo-Pastorale
SODEVA	Société de Développement et de Vulgarisation Agricole
STN	Société des Terres Neuves
SWF	Service of Waters and Forests (Eaux et Forêts)
UIPE	Union Internationale pour la Protection de l'Enfance
UNDP (PNUD)	United Nations Development Program
UNSO	United Nations Sahel Office
USAID	United States Agency for International Development
WFP (PAM)	World Food Program

EXECUTIVE SUMMARY

A. FRAMEWORK

1. Introduction

This paper analyzes and synthesizes original field data--based on research conducted in Senegal under a Fulbright Grant (October 1982 to August 1983)--with complementary research undertaken at the Yale School of Forestry and Environmental Studies.

There are two foci: (1) planning, programming and research at the national level and (2) the case level represented by the examination of 20 current reforestation projects.

The objectives are to analyze and compare the alternative approaches to reforestation, to extract lessons from the case studies, and to interpret the implications of these findings for future reforestation efforts in Senegal and the Sahel.

2. Overview

2.1 National Reforestation Program. The Service of Water and Forests (SWF) is the steward of the national forest reserves. Reforestation activities are carried out in state-managed forests and in the private rural sector.

Between 1961 and 1982, approximately 50,000 hectares received reforestation efforts and 1150 kilometers of roads were planted with trees. Survival rates of these activities were extremely variable, ranging from complete failure to over 90 percent. In addition, more than six million seedlings were distributed without charge to the populace for individual and collective plantings; the FAO (1981a) estimated an overall survival of 20 percent for these trees.

In the current reforestation program, over three-quarters of the work is done by projects granted an "autonomous" status to facilitate greater decentralization of financial and managerial functions. These projects rely heavily on foreign funding mechanisms.

2.2 Master Plan for Forestry Development. The Master Plan (CTFT/SCET 1982) is one of the first attempts among African nations to develop a long-range, comprehensive strategy for the forestry sector.

The major components of the Plan are: (1) a "diagnostic" part that inventories and projects supply and demand trends to 2016, (2) a long-term strategy for forestry development, and (3) a short- and medium-term strategy (1982-1996) that details specific actions to support the long-term goals.

2.3 Forestry research. CNRF is the lead forestry research institution in Senegal. Presently, funding constraints limit their range of research activities.

Some major areas of research are: eucalypts--species and provenance trials, plantation establishment techniques and long-term ecological effects; reforestation on saline "tanns" soils; Australian acacias--species and provenance testing, fodder and biomass production; genetic improvement and sylviculture of gum arabic (*Acacia senegal*) and tree forage species; and irrigated plantations. Research is gradually starting in the vital area of natural forest management.

B. DESCRIPTION OF PROJECTS

Table i summarizes some basic parameters of the reforestation projects examined in this study.

3. Coastal "Niayes" Zone

The "niayes" zone, located interior of the coastal dunes that extend from Dakar to Saint-Louis, is an important food-producing area owing to a very shallow and non-saline water table. This area of truck-market gardening is being threatened by dune encroachment caused by the northerly "alizé" winds.

Efforts to stabilize marine dunes by planting the filao (*Casuarina equisetifolia*) can be traced to successful planting trials that began as early as 1908. The French agronomist Etesse (1918) expressed hope that one day the entire "Grande Côte," the 180-kilometer coastline between Dakar and Saint-Louis , would be protected with a band of planted filao. This hope has been recently fulfilled.

4. Large-scale Fuelwood Production

The rationale for large-scale, "peri-urban" plantations is two-fold: (1) to increase yields and reduce fuelwood transportation costs by establishing large tracts of fast-growing, exotic species near urban centers and (2) to ease the pressure on natural forests in southern and eastern Senegal that are heavily exploited to produce charcoal for the urban markets.

Table i

Basic parameters of reforestation projects in Senegal.

		External Funding					
Type	Project	Source	Projected Amount (million US$)	Start-up Year	Principal Species	Reforestation Accomplishments (ha as of 12/82)	Intervention Levels
Dune Stabilization	Gandiol	Canada (CIDA)	0.2	1979	*Casuarina equisetifolia* (filao)	650	State
	FAO	UNDP	0.7	1975	*C. equisetifolia* + diverse spp.	4100	State
	PL-480	USAID (Title III)	?	1981	*C. equisetifolia*	1400	State
Large-Scale Fuelwood Production	PARFOB	USAID	3.1	1980	*E. camaldulensis*	1555	State
	PARCE	France, World Bank	10.0	1979	*E. camaldulensis*	500	State, Rural Community (R.C.)
Groundnut Basin	PRECOBA	Finland/FAO	0.7	1981	*E. camaldulensis* + *Acacia albida*	656	R.C.
	Louga Community Reforestation	Sweden/FAO	1.4	1983	diverse species	--	R.C.
	Africare Community Woodlots	USAID	0.1	1980	*E. camaldulensis*	190	R.C.
	Diourbel Village Reforestation	USAID	0.2	1980	diverse species	159	Village
	SODEVA	USAID + other	?	1968	diverse species	?	Individual, Village
	PASA	Germany (GTZ)	3.1	1980	*Anacardium occidentale* (cashew)	5820	All Levels

Table I (cont.)

Basic parameters of reforestation projects in Senegal.

Sylvo-Pastoral Zone	Mbiddi Experimental Center	Canada (IDRC)	0.7	1973	*Acacia Senegal* + tree forage spp.	325	Experimental
	German Sylvo-Pastoral Reforestation	Germany (GTZ)	4.2	1975	*A. senegal*	>5000	State, Village
	Lagbar Integrated Development	UIPE (Switzerland)	?	1978	*A. senegal* + *A. tortilis*	314	Village
	SODESP	USAID	8.0 (15% of activities are reforestation)	1975	*A. senegal*	?	Individual
Senegal River Basin	Nianga Irrigated Plantations	France (FAC)	0.1	1979	*E. camaldulensis* + diverse spp.	20	Experimental
	Gonakier Reforestation	Holland	pending		*Acacia nilotica*	--	State, R.C.
	Podor Gum Arabic Plantations	FED	?	1983	*A. senegal*	--	R.C.
	Bakel Community Afforestation	Sweden/FAO	1.4	1983	*A. senegal* + fruit trees	--	R.C.

Many problems have emerged from pilot efforts due to: low rainfall; susceptibility of *Eucalyptus camaldulensis* to drought, termites and competition from herbaceous plants; and problems with the upkeep of heavy equipment used in mechanized site preparation and weeding. These factors have contributed to yields that are expected to be disappointingly low and economically infeasible.

5. Groundnut Basin

The Groundnut Basin is one of the oldest areas of cash-crop agriculture in West Africa and produces the most important Senegalese export. The high population pressure in the Basin, exceeding 100 inhabitants per square kilometer in some portions, has led to agricultural expansion and reduced or abandoned fallowing periods. The resulting environmental degradation and declining agricultural yields have been aggravated by recent droughty conditions.

Reforestation efforts in the Basin must ultimately work within the severe land constraint. Extension is vital; so are forestry interventions that can sustain or improve soil fertility and productivity. Agroforestry applications may be a means of circumventing the land constraint while improving agricultural productivity and providing tree products. Existing activities include: the promotion of the *Acacia albida*-millet system indigenous to the Serer ethnic group; the intercropping of groundnuts or garden vegetables in small woodlots; and the establishment of windbreaks.

6. Sylvo-pastoral Zone

The sylvo-pastoral zone extends over northern and central Senegal, an area commonly called the Ferlo. Over 70 deep wells have been bored, about 30 to 40 kilometers from each other, in this zone (Fleury 1982). Recent droughts, increased numbers of livestock and agricultural expansion into the zone have caused extensive deterioration of the rangelands; areas adjacent to watering points have suffered the greatest livestock depredations.

There are two reforestation priorities, both supported by research at the Mbiddi Experimental Center. First is the establishment of *Acacia senegal* plantations. This species yields an important export commodity--gum arabic. Second is the planting of forage tree species to rehabilitate degraded areas surrounding wells and to provide fodder for livestock.

7. Senegal River Basin

The Fleuve Region contains the Senegal River, an important waterway that originates in Guinea and flows through Mali, Mauritania and Senegal. Traditional livelihoods include fishing and "double-cropping," rainfed agriculture on higher lands and recessional farming on floodplains. The OMVS project--a $500 million multinationally-managed, hydro-agricultural complex--is expected to have overwhelming impacts on the natural and social ecology of the Basin.

Of particular concern are further losses of *Acacia nilotica* expected from planned dam impoundments and conversion of forests to irrigated farmland. Heavy mortality in the gonakier forest type has already resulted from the recent droughts. Some potential compensating measures are: the reforestation of the gonakier by enrichment seeding, planting or protection of natural regeneration; the planting of windbreaks in irrigated perimeters; and the planting of gum arabic, forage and fuelwood trees near villages and other settlements.

C. ANALYSIS

8. Constraints

A variety of ecological, technical, social and institutional constraints impinge on reforestation efforts in Senegal.

The harsh Sahelian climate--characterized by the low and erratic distribution of "mosaic rains" and the high evapotranspiration demand--combined with edaphic factors that are often unfavorable for tree growth--lateritic hardpans, low fertility, high salinity, and periodic inundation--present tough ecological parameters for tree survival.

Many technical problems remain unsolved. Two persistent constraints to plantation efforts are (1) the lack of suitable, "fast-growing" exotics that can withstand the environmental stresses and maintain desirable production rates and (2) technical packages that are not cost-effective and, therefore, unlikely to be locally sustainable in the absence of external funding.

Social constraints to reforestation are extremely complex; they often are the limiting factors that determine success or failure. In analyzing the project case studies, the following issues appear almost universally, although in different forms and nuances: land availability (especially in the congested Groundnut Basin); labor availability and seasonal conflicts with agricultural demand; the perception of "equity" in the distribution of future benefits; and the prevailing land and tree tenureship, superimposing both customary and formal systems of resource regulation.

Institutional constraints relate to the low "absorptive capacity" of the SWF. Projected levels of both funding and staffing will be insufficient for the program strategy envisioned in the Master Plan for Forestry Development.

9. Implications

9.1 Planning level. The Master Plan represents an important step in correcting the short-sightedness inherent in many foreign-assisted efforts in Sahelian forestry. However, the Plan appears to be biased toward (1) massive plantation establishment as the key strategy and (2) short-term, externally-funded projects as the key vehicle for attaining reforestation goals. This orientation ignores the underlying "process and context" (Taylor and Soumaré 1983) that is crucial to reforestation success.

9.2 Project level. Many lessons can be learned from the accumulated knowledge and experience of reforestation projects in Senegal. That is one of the primary functions implicit in the pilot nature of most projects.

Deficiencies in the project design phase--including erroneous assumptions about technical or social factors--have caused many problems. Perhaps a transitional period between "design" and "implementation" of projects would be helpful in order to better assess the local context as well as attend to the mundane and lengthy (but necessary) logistical procedures. The alternative approaches and techniques used in reforestation projects will provide a valuable, comparative basis for generalization and prescription. Some preliminary trends, as to "what works best" in different situations, are already emerging.

9.3 Research level. Two caveats must be addressed regarding forestry research. First, there needs to be better integration--both physical and philosophical--between CNRF and the SWF in identifying priorities and conducting useful, applied research that is tied to operational projects. Second, effective channels of dissemination must be developed so that meaningful research findings will reach field foresters.

10. Discussion and Recommendations

The following issues appear to be ones that will have great bearing on the fate of present reforestation efforts as well as the development of a broader, "process-and-context" orientation for future activities in Senegal and the Sahel:

* collaboration--between donor and implementation agencies; between agriculture and forestry services.

* sustainability--shift toward technologies that are locally sustainable in terms of the available human, ecological and financial resources.

* replicability--systematic diffusion of successful models of reforestation through effective extension and demonstration.

* institutional reform and strengthening--revision of national forestry code; reorientation of forester from police to extension agent.

* private sector initiative--"privatization" of tree ownership rights; use of market system incentives; self-policing of the forest resource by local communities.

* natural forest management--increase productivity of forest reserves through protection and management; promote "anthropogenic" forest parklands indigenously utilized for agroforestry.

REFORESTATION IN THE REPUBLIC OF SENEGAL: FRAMEWORK, DESCRIPTION, AND ANALYSIS

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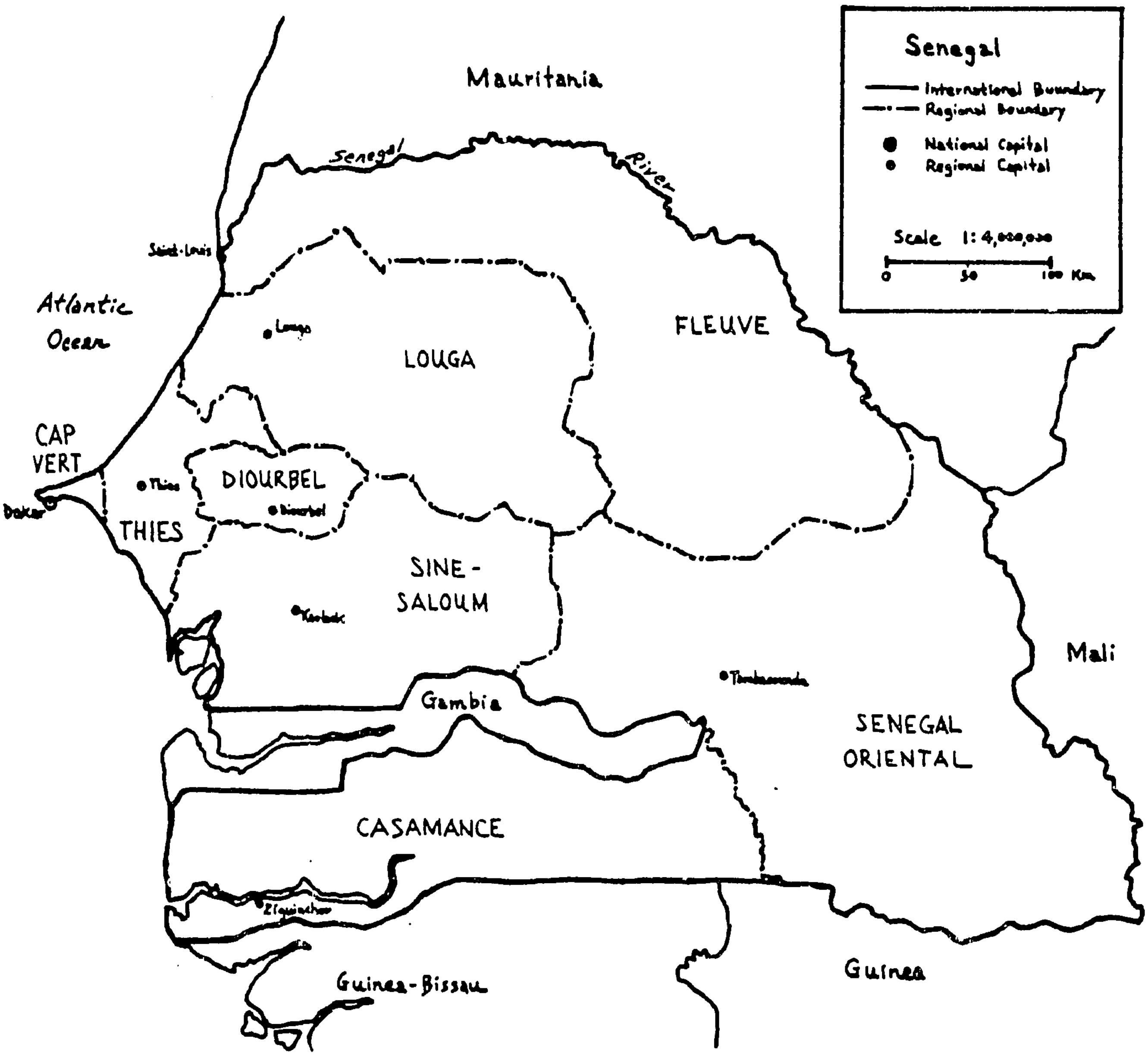
FRAMEWORK:

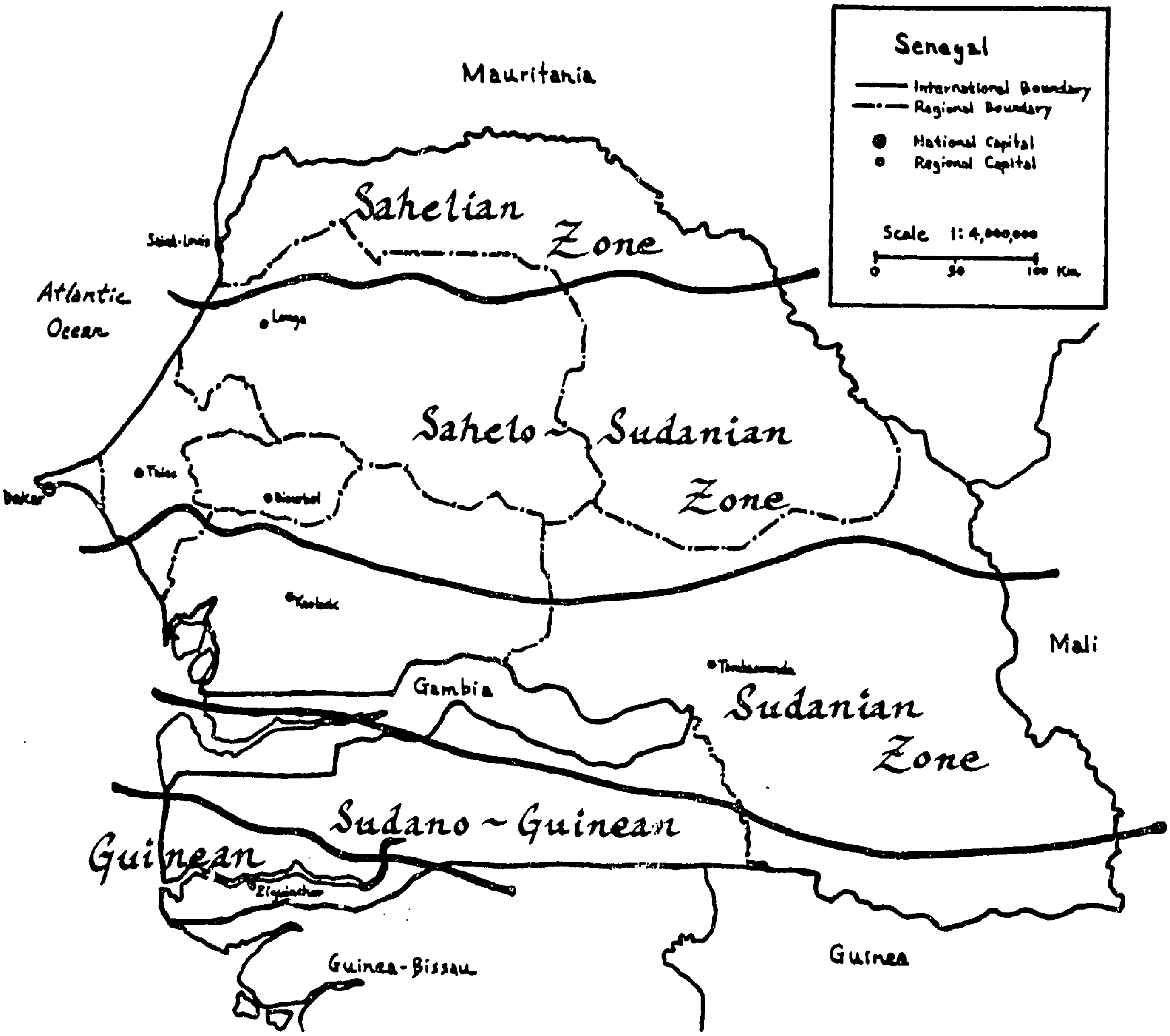
PAST, PRESENT, ANC

TRENDS

MAP 1. ADMINISTRATIVE REGIONS OF SENEGAL.



MAP 2. BIOGEOGRAPHIC ZONES.



1. INTRODUCTION

The Sahel region of West Africa is a troubled zone. Sahelians must cope with a dry, marginally-productive ecosystem that is put under greater stress by increasing human and animal populations, expanding agriculture, along with periodic drought. The region has yet to recover from the severe drought circa 1968-1973 and droughty conditions have again prevailed during the past few years.

Sahelians are largely dependent upon fuelwood--firewood and charcoal--for cooking and various other needs (e.g., the smoke-curing of fish). Within the region, fuelwood accounts for 60 to 90 percent of the total energy consumed (CILSS/Club du Sahel 1978). However, localized fuelwood shortages are occurring throughout the Sahel, due mainly to the stresses cited above. One response to this problem has been a dramatic increase in forestry efforts. A CILSS/Club du Sahel study revealed that in the period 1975 to 1982, donor agencies have spent more than $160 million for forestry and ecology projects in the Sahel. Results have been unsatisfactory; only an estimated 20,000 hectares of plantations may be growing at "reasonable" production rates (Weber 1982).

1.1 Problem Definition

In this growing myriad of international and bilateral donor organizations, regional development agencies, non-governmental organizations, parapublic rural development agencies, and host country forestry services, how can one learn about (and from) what is actually occurring on the ground? One opportunity would be to examine in depth the reforestation program of a Sahelian country. The Republic of Senegal offers many advantages for being the focus of such an examination. (Editorial note: The term "reforestation" will be used throughout this paper for the sake of simplicity. Admittedly, there are cases where afforestation would be the appropriate terminology--e.g., dune stabilization plantings. However, there are many ambiguous cases where the judicious choice of "reforestation" versus "afforestation" would have to depend on the rather subjective and arbitrary interpretation of what constitues a "prolonged period" of treelessness.)

Senegal, by virtue of her favored status during the colonial era, has an intellectual elite unsurpassed by other Sahelian countries. The cadre of Senegalese forestry personnel is well-trained and technically competent. The history of reforestation in Senegal dates to the 1930s. However, the recent proliferation of forestry projects has created a somewhat chaotic situation with regard to insufficient coordination and collaboration between different donor and implementing agencies.

With expatriate consultants and foresters from many countries--France, Belgium, Germany, Denmark, Canada, the United States and others--assisting in more than 20 operational projects, many collaborative opportunities have been missed. The plethora of projects, organizations and personalities has led to a situation in which there is inadequate exchange of ideas and information. Many projects operate in a vacuum; few donors are well informed about activities outside of their immediate area of concern. This is indeed unfortunate since so much can be learned from the base of knowledge that already exists or is just emerging. Mistakes and duplication of effort may be avoided. Different reforestation approaches and techniques can be compared. Lessons and implications can be drawn and applied to current and future efforts. It was this premise that stimulated the present endeavor.

1.2 Purpose, Scope and Methodology

Field work was conducted in Senegal from October 1982 to August 1983 and made possible by the award of a Fulbright Research Grant. This study concentrated on 20 reforestation projects situated in the Sahelian and Sudanian zones--from the Senegal River southward to Gambia. All of the administrative regions of Senegal are included in this area except the Casamance Region (See Maps 1 and 2). Information concerning these projects were obtained by site visits, interviews and literature review.

This paper represents an analysis and synthesis of the original field data, complemented by additional research conducted under the aegis of a Special Project at the Yale School of Forestry and Environmental Studies. The objectives are: (1) to provide an overview of the national reforestation program as well as forestry planning and research; (2) to systematically present the current status of reforestation projects; and (3) to analyze the different approaches and relevant constraints in order to extract implications for future efforts in reforestation in Senegal and the Sahel.

2. OVERVIEW

2.1 National Reforestation Program

2.11 Historical perspective. The Republic of Senegal has a historical precedent of reforestation activities. Filao (*Casuarina equisetifolia*) trials that began in 1908 evolved into operational programs of dune stabilization beginning in 1947 with the first filao plantations in the Cap Vert Region. In the Casamance Region, reforestation with teak (*Tectona grandis*) began in 1936; *Gmelina arborea* was introduced shortly thereafter and now supplies the Senegalese matchstick industry. In the 1960s, cashew (*Anacardium occidentale*) was used extensively in plantations and roadside plantings in the Casamance, Sine-Saloum, Thies and Cap Vert Regions. During the same period, neems (*Azadirachta indica*) were planted along roads and in villages throughout Senegal. The neem remains the most resistant and visible exotic species in the Sahelian landscape. The promotion of *Acacia albida*--protection and selection of natural regeneration as well as interplanting in fields--began in the mid-1960s.

The severe drought of 1968 to 1973 prompted the international donor community to orchestrate with the Government of Senegal an accelerated program of anti-desertification and reforestation efforts. Thus, one witnessed the gestation of the Mbiddi Experimental Center (1973), the German-financed project in the sylvo-pastoral zone (1975), and the FAO dune stabilization project based in Kebemer (1975). In the second half of the decade, global awareness of the "other energy crisis" (Eckholm 1975) launched a trend toward plantations of fast-growing, exotic species to address the fuelwood problem. In Senegal, as in much of the Sahel, *Eucalyptus camaldulensis* was hailed as the new "miracle tree." However, with the growing realization that *E. camaldulensis* is ill-suited to the harsh ecological factors and complex socio-economic conditions that prevail, the current emphasis is on social forestry and the greater use of indigenous, multiple-use species.

2.12 Service of Waters and Forests (SWF). The SWF (Service des Eaux et Forêts) is the steward of the national forest reserves ("forêts classés") and conducts reforestation activities in some of these reserves. Starting in 1959, efforts were initiated to include all Senegalese in the national reforestation program. This includes the distribution of free seedlings to rural and urban populations for individual, collective or roadside plantings. Over six million seedlings were distributed between 1961 and 1982; FAO (1981a) estimated an overall survival rate of 20 percent for seedlings distributed to and planted by the population.

These activities are being increasingly politicized. The President and some of his top-level staff inaugurate the national reforestation campaign and symbolically plant trees in different localities on "National Arbor Day." The media--in particular radio broadcasters and newspapers--are used extensively to engage popular support and participation.

Reforestation work carried out by the Regional Inspectorates of the SWF in conjunction with local populations include:

* community, village or individual woodlots (fuelwood, *Acacia albida*, forage and fruit trees);

* windbreaks;

* line plantings along roads ("axes routiers");

* distribution of seedlings to individuals for planting in family compounds, village public places and urban settings.

In recent years, "food for work" from the World Food Program (WFP/PAM) has been distributed for local participation in reforestation activities. The WFP project (SEN 2236) began in 1978, the second phase expired at the end of 1983, and a possible third phase of the project is under study (Ndiaye, A. 1983a). The "vivres PAM" ration for one equivalent man-day of work is 2.5 kilograms of sorghum or other cereal, 125 grams of canned meat, 125 grams of canned fish and 100 grams of vegetable oil. The general guidelines for distribution of food are given in Table 1.

Table 1

"Food for work" equivalent man-days for certain reforestation activities.

Reforestation activity	Equivalent man-days	
Village woodlot	40/ha	
Acacia albida plantation	80/ha	40% after planting 60% after protection
Windbreak	80/km	
Roadside planting	15/km	

Source: Diallo 1983

2.13 Reforestation accomplishments. For the post-independence period 1961-1982, approximately 50,000 hectares received reforestation efforts, 1150 kilometers of roads were lined with planted trees, and more than 6,000,000 seedlings were distributed to the population. Survival rates of these trees are highly variable, ranging from complete failure to rates exceeding 90 percent. As mentioned, the survival of free seedlings distributed to the populace may be on the order of one in five; first-year survival counts conducted by the SWF--before the hot, dry season--ranged from 35 to 55 percent (FAO 1981a).

In the current reforestation program, over three-quarters of the work is carried out under the auspices of the projects examined in this study. By administrative decree, almost all of these projects are granted an autonomous status to permit greater decentralization of financial and managerial functions.

Table 2 presents the reforestation accomplishments from 1961 to 1977 in periods that correspond with the four-year National Development Plans (the Senegalese fiscal year begins on July 1). As noted earlier, the first autonomous projects began during the Fourth Plan (1973-1977).

The acceleration of reforestation efforts was quite rapid during the period 1977 to 1982, as indicated by the summary of yearly results in Table 3. Table 4 shows the reforestation program planned for 1983, which was only partially realized due to a lack of rainfall; note the proportion of the program slated for the autonomous projects.

Table 2

Reforestation activities between 1961 and 1977.

Reforestation activity	Accomplishments during the period: 1st plan 1961-1965	2nd plan 1965-1969	3rd plan 1969-1973	4th plan 1973-1977	Total
Teak/Gmelina	500	838	800	600	2,738 ha
Cashew distribution	individual	4,000 distribution	individual	800	4,800
Acacia albida		11,000*	990	500	12,490
Filao		400	100	300	800
Sylvo-pastoral				900	900
"Peri-urban"				400	400
Senegal River Delta				300	300
Total	500+	16,238	1,890+	3,800	22,428+ ha
Distribution of free seedlings	795,982	950,490	957,807	1,037,717	3,741,996
Roadside plantings	no breakdown available				120 km

Source; République du Sénégal 1983a

* largely protection of natural regeneration.

Table 3

Reforestation activities between 1977 and 1982.

Year	Plantations (ha) State Managed	Community and Village	Total	Roadside Plantings (km)	Distribution of Seedlings (plants)
1977	1,119	210	1,409	218	420,000
1978	1,535	200	1,735	174	440,000
1979	1,613	347	1,960	166	280,000
1980	2,605	1,772	4,377	60	304,000
1981	4.691	4,465	9,156	195	327,000
1982	3,900	4,811	8,711	221	571,000
Total	15,543	11,805	27,348	1,034	2,342,000

Source: République du Sénégal 1983a

2.2 Master Plan for Forestry Development

The Master Plan for Forestry Development is a multi-volume document. The work was financed by French foreign aid and the Caisse Centrale de Coopération Economique (CCCE) and was carried out between 1979 and 1982 by the Centre Technique Forestier Tropical (CTFT) and SCET International (a private French consulting group) in collaboration with Senegalese forestry personnel. The Master Plan is one of the first attempts among West African nations to develop a long-range, comprehensive plan for the forestry sector.

Table 4

Planned reforestation program for 1983.

Implementation by:	*Plantations (ha)* State Managed	Community and Village	Total	Roadside Plantings (km)	Distribution of Seedlings (plants)
Reforestation projects	3,316	4,955	8,271		
SWF Regional Inspectorates	394	1,083	1,477	519	860,000
Total	3,710	6,038	9,748	519	860,000

Source: République du Sénégal 1983a

Three major components of the Plan are : (1) a "diagnostic" part that inventories and evaluates the forest resources, projects wood supply and demand trends to the year 2016, and reviews constraints to forestry development; (2) a long-term strategy (2000 and beyond) for forestry development; and (3) a short- and medium-term strategy (1982-1996) that details specific activities to support the long-term goals. This last component includes parameters for a desirable program of action (contingent on a high level of external financing) and a reduced program (based on lower funding levels) that is considered to be the minimum required to avoid a catastrophic situation by the year 2000.

2.21 Forest resources. At the end of 1978, Senegal had 13.8 million hectares of woody vegetation cover ranging from dense forests (226,000 hectares--of which 168,000 were mangrove formations) to shrubby "steppe" vegetation (2.2 million hectares). This woody cover represented 70 percent of the total land surface of 197,000 square kilometers (Jeune Afrique 1980). Over one-half of the land containing woody vegetation was in a reserved or regulated status (Table 5).

Table 5

Reserved or regulated forest land.

Type	Number	Surface area (million ha)
Forest reserves ("forêts classées")	145	1.3
Managed forests ("forêts aménagées")	19	0.2
Sylvo-pastoral reserves	20	1.5
Fauna reserves	4	1.2
Controlled hunting areas	9	2.0
National parks	6	1.0

Sources: : République du Sénégal 1980
CTFT/SCET 1982a

An estimated total of 139 million cubic meters of standing volume (10 centimeters or greater in diameter) existed for all woody vegetation types. The extensive savanna types--which occur mostly in the sparsely populated Senegal Oriental Region--accounted for roughly 100 million cubic meters of the total wood volume.

2.22 Fuelwood consumption. Present per capita consumption of fuelwood on an annual basis is assumed to be 0.85 cubic meter in rural areas and 0.65 cubic meter in the urban sector. Fuelwood accounts for 60 percent of the total energy consumption in Senegal. In rural areas, firewood is virtually the sole source of energy, meeting 96 percent of rural energy demands. Charcoal is the predominant form of fuelwood in urban areas; 500,000 tonnes were sold in Dakar in 1980 at controlled prices deemed by many experts to be artificially low (30 FCFA per kilogram). Studies have begun on the real costs of fuelwood production, conversion and transportation and the implications of pricing policies (Ruche 1983).

The regional disparities in the potential production and consumption of wood are evident in the data presented in Table 6. Over 50 percent of the available fuelwood supply is located in the extensive savanna formations of the Senegal Oriental Region--geographically, the most distant area from the regions of greatest fuelwood deficit: Cap Vert, Thies and Diourbel.

Table 6

Estimated annual production* and consumption of wood
by Regions and end uses (as of June 1981).

	Fuelwood			Construction Wood		Timber	
	Production	Consumption	Surplus or Deficit	Production	Consumption	Production	Exploitation
Region	(thousands of m^3)		(m^3 per capita)	(thousands of m^3)		(thousands of m^3)	
Cap Vert	nil	820	» -0.6	nil	» 230	0	0
Thies/Diourbel	49	1,011		6		nil	nil
Louga	160	385	-0.2	18	85	nil	nil
Fleuve	272	465	-0.1	37	90	nil	nil
Sine-Saloum	296	940	-0.3	42	200	nil	nil
Senegal Oriental	3,823	263	+9.5	555	55	22	5
Casamonce	2,561	666	+1.6	567	140	68	20
Total	7,161	4,550	+0.4**	1,225	800	90	25

Sources: FAO 1981a
CTFT/SCET 1982a

* excludes reserved and protected forest areas (e.g. mangroves)
** assumes a population of 5.9 million in mid-1981

Assuming an annual population growth of 2.8 percent and reductions in fuelwood consumption per capita due to conservation measures (e.g., "Ban ak suuf" improved cookstoves) and alternative energy sources (e.g., groundnut shell briquets, peat, solar), fuelwood demand in the rural and urban sectors is projected as such:

	Per capita fuelwood demand		Total fuelwood demand		
Year	*Rural*	*Urban*	*Rural*	*Urban*	*Total*
	(m^3/inhabitant/year)		(thousands of m^3)		
1981	0.85	0.65	3,300	1,250	4,550
2000	0.75	0.60	3,680	2,830	6,540
2016	0.65	0.55	3,545	4,595	8,140

National wood supplies and demands for the years 2000 and 2016 are projected in Table 7.

Based on the estimated and projected trends of fuelwood supply and demand, deficits at the national level are not expected to emerge until after the turn of the century. However, serious problems are associated with the regional imbalance of fuelwood supply and demand. Already, charcoal is transported over 500 kilometers or more from Senegal Oriental to Dakar. The urban growth rate was 4.1 percent in 1978 (7 percent for Dakar) as compared to one percent in rural areas (ETI 1982). The continuing rural exodus will further exacerbate regional shortages of fuelwood.

2.23 Deforestation. For the period 1976 to 1980, clearing of woody vegetation for agricultural purposes proceeded at an estimated annual

Table 7

Projected supplies and demands of wood in 2000 and 2016

(all units in thousands of m³)

Year	End Use	Supply from: Natural Forests	Supply from: Plantations	Total Demand	National Surplus or deficit
2000	Fuel wood	6,300	236	6,500	+ 26
	Construction Wood	1,100	506	8,140	+183
	Timber	25	4	160	-131
	Pulp	0	0	300*	-300
2016	Fuel wood	5,300	506	8,140	-2,334
	Construction Wood	900	71	1,100	+ 80
	Timber	25	20	250	-205
	Pulp	0	0	540*	-540

Source: CTFT/SCET 1982a

* roundwood equivalent of imported pulp

rate of 40,000 hectares. Due to resettlement projects aimed at alleviating the population pressures of the Groundnut Basin, agricultural colonization of the "new lands"--Kaffrine and Tambacounda Departments--will likely increase this type of deforestation to an estimated 50,000 hectares per year of savanna vegetation between 1981 and 1985.

In the "steppe" formations of the Louga and Fleuve Regions, agricultural clearing and fuelwood cuttings may cause rates of deforestation approaching 20,000 hectares per year during the period 1981 to 2000.

In addition to the actual clearing of woody vegetation, degradation of the forest resource as a result of overcutting, overgrazing, and fire may lead to an annual loss of one to two percent of the total forest vegetation.

At these estimated rates, the forest cover will be reduced from 13.8 million hectares in 1978 to 11.6 million by the end of the century (FAO 1981a, CTFT/SCET 1982a).

2.24 Long-term strategy. Five long-term goals are articulated in the Master Plan:

* conserve the forest resource potential;
* satisfy priority needs for forest products;
* improve rural living conditions by supplying energy and supporting food production;
* reduce dependence on imports by developing national supplies of forest products.

To meet most of the projected fuelwood demand in the rural sector in 2016, 60,000 hectares of natural forests or plantations have to be harvested. To fulfill the urban charcoal demand projected for 2000, 440,000 tonnes would have to be supplied by plantations and 335,000 tonnes by natural forests. This would require the following *annual* rates of plantation establishment:

By year:	*Hectares*:
1991	9,360
1996	10,370
2001	28,740

The area in forest reserves considered to be suitable for plantations is 231,750 hectares--mostly in the remote areas of eastern Casamance and Senegal Oriental. Given the scarcity of suitable sites on state-managed lands, more than one-half of the projected fuelwood plantings would have to be accomplished in the private rural sector (CTFT/SCET 1982b).

2.25 Short- and medium-term strategy. This strategy involves an implementation program for the short term (July 1, 1982 to June 30, 1989 covering the last three years of the Sixth National Plan and the entire Seventh Plan) and the medium term (July 1, 1989 to June 30, 1997 covering the Eighth and Ninth Plans). Six objectives are set forth:

1. reduce regional shortages of fuelwood for rural populations;
2. meet the fuelwood requirements of urban populations;
3. increase the percentage of nationally produced timber;
4. increase the production of the main exportable forest products: gum arabic and cashew nuts;

5. initiate industrial projects related to the use of wood biomass: paper, pulp and energy;
6. conserve and protect biotic communities and maintain the equilibrium of natural ecosystems.

To meet the projected fuelwood needs at the end of the century, a total of 142,000 hectares of plantations would have to be established on state-managed lands and 220,000 hectares on community or private lands.

2.3 Forestry Research

The National Center of Forestry Research (CNRF) was established in 1974 as a branch of the Senegalese Institute of Agricultural Research (ISRA). A cooperative agreement exists whereby France pays the salaries of French researchers assigned to CNRF, while Senegal coordinates the functioning of the research institute.

Funding is from national (e.g., the "Fonds Forestier National") and international (e.g., FAC, CCCE, USAID, IDRC, World Bank) sources. Funding levels have declined over the period 1978 to 1981 and in 1980/81, the 56 million FCFA budget for CNRF represented only 2.6 percent of the total budget of ISRA. For the fiscal year 1981/82, the CNRF budget was reduced by an additional 20 percent (CTFT/SCET 1982a). CNRF collaborates with other research organizations, such as ORSTOM and the University of Dakar, and conducts some complementary research with operational forestry projects. Some important areas of research are summarized below:

2.31 Eucalyptus.

(a) *Species and provenance trials.* Since 1967, more than 70 species of *Eucalyptus* have been established in test plots throughout Senegal. These trial plantings included 120 provenances of *E. camaldulensis*, 30 provenances of *E. microtheca*, and 20 provenances of *E. tereticornis*. For *E. camaldulensis*, the two provenances that have shown the most promise originate from Georgetown, Queensland State (8298/FTB) and Derby, Western Australia State (8411/FTB)(Hamel and Bailly 1981a). Certain site and growth characteristics are presented in Table 8.

These data underscore two important characteristics of *E. camaldulensis*. The first is the riparian nature of this species in its native range in Australia, where availability of soil moisture is more a function of periodic flooding and high water tables than rainfall amounts (Grunwald and Karschon 1982). Secondly, because *E. camaldulensis* is generally uneconomical in water usage--stomatal closure occurring only at the stage of permanent wilt--a high proportion of its energy allocation must go to maintenance respiration as opposed to wood production. Thus, the evapotranspiration demand plays an important role in determining the suitability of a site because of its influence on the energy allocation process of *E. camaldulensis*. This may explain the failure of provenance trials at the Linguere station (not included in Table 8), where the annual evapotranspiration demand was 4241 millimeters. On the other hand, the low coastal evapotranspiration rate combined with a shallow, non-saline water table appears to account for the excellent growth rate registered at Mbao, despite receiving the lowest average annual rainfall of the four stations.

Table 8

Selected site and growth characteristics for *E. camaldulensis* provenance trials

Station	Year of establishment	Average rainfall since est (mm/yr)	Evapotranspiration demand (mm/yr)	Estimated depth of water table (m)	Plantation Spacing (m×m)	Provenance	Growth rate as of 12/80 (m^3/ha/yr)
Mbao	1968	333	907	3	4×4	8411/FTB	12.0
Bambey	1972	457	2877	25*	3×3	7791/FTB	2.2
Keur-Mactar	1973	514	2664	3*	3×3	8298/FTB	6.3
Bandia	1976	431	n.a. (less than Bambey values)	n.a. (less than Bambey values)	3.5×3.5	979-87/CTFT	4.4

Source: Hamel and Bailly 1981a

* saline groundwater

Based on the preliminary findings of these trials, the following recommendations were made regarding species selections from the *Eucalyptus* genus (Hamel and Bailly 1981a):

* *E. tereticornis* for the Guinean zone (Casamance Region).
  --23.2 cubic meters per hectare per year growth rate at the Bayottes Station.

* *E. microtheca* for very compact and clayey "deck dur" soils in the Groundnut Basin.
  --3.4 cubic meters per hectare per year growth rate at Bambey, the best of any species tested there.

* *E. camaldulensis* for sites in the Groundnut Basin that:
  --have an annual rainfall superior to 500 millimeters (or are situated in coastal areas with lesser evapotranspiration rates);
  --have permeable root zonesof at least one meter in depth;
  --first harvest cut to be carried out when total accumulated rainfall reaches 2,500 millimeters (the production function appears to flatten out after this point).

(b) *Plantation establishment*. The first component of the complementary research funded by USAID and conducted by CNRF within the framework of the PARFOB project (section 4.1) is aimed at reducing the costs of plantation establishment. Beginning in 1980, CNRF has installed a series of research plots among the planted compartments of *E. camaldulensis* at the Bandia Forest. The purpose is to assess the effectiveness, from both technical and economic standpoints, of alternative methods of plantation establishment (Bailly 1983). Experimentation to date included:

1. "*barbatelle*" (*stump*) *planting*--50 hectares were planted in 1982 with stump stock (half root, half shoot, leaves removed) of 8 millimeters and greater in stem diameter.

Average planting rates with "barbatelles" were 700-800 per person per day as opposed to only 200-300 for conventional seedlings in plastic pots ("polipots"). Use of "barbatelles" precludes the need for soil transport--an estimated 600 tonnes of soil were trucked to the Bandia nursery in 1982 to fill the "polipots"--and the actual pot filling operation. One disadvantage is that "barbatelles" require a minimum of seven months in the nursery as opposed to three or four months for potted stock. Therefore, *Eucalyptus* to be produced as "barbatelles" must be sown in December or January, the coolest period of the year, and early seedling development is slow (Lô 1983). The "barbatelles" planted in 1982 had an estimated first-year survival rate of 50-60 percent, significantly lower than potted eucalypts that were outplanted in 1982 (70-95 percent year-end survival).

2. *herbicide application*--nine hectares were treated in 1982 with two different chemicals applied by a tractor-mounted device. The principle advantage is that tractor operating time is less in herbicide application than in mechanized weeding (one-half hour per hectare versus two hours). However, the beneficial effects of disc harrowing--soil aeration, breaking up lateritic formations--are foregone in chemical weeding. Herbicide treatments kept the ground free of weeds for about two months.

3. *agroforestry*--test plots were established in 1981 for the intercropping of groundnuts, pigeon peas ("niébé"), and millet between eucalypts planted at spacings of five by three and seven by three meters. Preliminary results indicated that a millet-*Eucalyptus* system is inappropriate because the millet rapidly overtopped the trees. However, there is potential with groundnut or pigeon pea intercropping and the simultaneous weeding of crops and trees. Realistically, agroforestry applications appear to be more suitable for community or individual woodlots than for large-scale plantations because of labor constraints.

(c) *Ecological effects*. Concerns about the long-term negative effects of *Eucalyptus* plantations revolve around two issues: hydrology and soil fertility.

Karschon and Heth (1967) found no evidence of adverse hydrological effects under *E. camaldulensis* plantations in Israel. However, preliminary findings from a water balance study conducted by CNRF at the Bandia Forest suggest a potential "water-pumping" effect; the soil moisture profile, as measured by neutron probes in a stand of eucalypts planted in 1980, indicated a three percent reduction in available soil moisture from December 1981 to December 1982 (Bailly 1983).

An ORSTOM study on the evolution of the soil under *E. camaldulensis* is based on bi-weekly collection and analysis of leaf litter and soil samples from two sites: Bandia Forest and the CNRF station at Keur Mactar. Results to date suggest that levels of nutrients and organic matter tend to decline in soils under this species. This is attributable to the slow rate of decomposition of the leaf litter and the tendency for mineralization or, in sandy soils, leaching of nutrients as opposed to humus production. Another research component, which just started, is an investigation into the possible allelopathic effects of *E. camaldulensis* on other vegetation (Bernhard-Reversat 1981a, 1981b, 1982).

2.32 Reforestation in Thies Region. Many exotic species, other than *Eucalyptus* spp., have been introduced on an experimental basis in the Thies Region, mostly as trial reforestation plantings in forest reserves. Of the 19 species of Australian acacias tested, *Acacia linarioides*, *A. holocericea*, and *A. bivenosa* have demonstrated superior survival and potential as forage species.

Prosopis cineraria has also performed well and has been used in direct seeding trials for the enrichment of degraded natural forests.

2.33 *Reforestation on "tanns" soils.* Beginning in 1971, research on appropriate species for reforestation on "tanns" or saline soils has been conducted at the CNRF station at Keur Mactar (Sine-Saloum Region). "Tanns" soils--virtual waste lands left bare by the dying off or removal of mangrove vegetation--present a formidable reforestation problem owing to their high salinity content, which can surpass 1.9 percent.

The most successful species have been those of *Melaleuca*, a halophytic genus originating from New Caledonia. These trees prefer clayey or loamey-clayey soils, can tolerate seasonal flooding, and, most importantly, are tolerant of salt contents up to 0.6 percent. *Melaleuca leucadendron* and *M. quinquinervia* have been selected as the best species for saline soils, especially those prone to periodic inundations. All eucalypts planted in 1971, at the same time as the *Melaleuca* ("niouli" in Wolof parlance), have perished due to excessive salt damage.

Of 11 other species planted in 1971, only two have demonstrated good adaptation to saline conditions; survival rates of *Acacia laeta* and *Prosopis juliflora* were 88 and 56 percent, respectively, in 1980.

Trials started in 1977 with Australian acacias have produced generally good results, particularly with *Acacia holocericea*, *A. linarioides*, *A. bivenosa*, and *A. sclerosperma*--all potentially good forage trees (Hamel and Bailly 1981b).

Two other research components being pursued are (1) the introduction of tree crops into local farming systems as windbreaks, field border plantings, and fuelwood plantings and (2) the genetic and sylvicultural improvement of *Melaleuca* spp. for use in rehabilitating saline waste lands (Seck 1983).

2.34 Natural forest management. Unfortunately, little baseline data exist on the actual and potential production of natural forests. The Master Plan pointed out the continuing degradation of natural forests due to a complex of factors: drought, brush fires, overgrazing and destruction of natural regeneration by livestock, overcutting for fuelwood, and removal of forest cover for agricultural expansion. In Senegal, annual growth rates in natural forests are estimated to range from nil to 0.25 cubic meter per hectare in the Sahelian zone and from 0.1 to 1.0 cubic meter per hectare further south in the Sahelo-Sudanian zone (CTFT/SCET 1981b).

Giffard (1974a) estimated that *Acacia seyal* forests, exploited over 20-year rotations in "managed forests" in the Thies Region, produced 0.7 to 1.0 cubic meter per hectare per year. In 1982, sample cuts were made in a nine-hectare block near the CNRF station at the Bandia Forest; the block was located in an *Acacia seyal* stand that had been exploited for charcoal production in 1976. Preliminary results from the sampling data indicated production rates ranging from 0.8 to 3.2 cubic meters per hectare per year (Freeman 1983).

Growth rates of natural forests appear to vary widely with micro-site factors, as well as with the degree of degradation incurred. The research being conducted by the PRECOBA project (section 5.1) in an *Acacia seyal* forest 40 kilometers southeast of Bandia should produce interesting comparative data on growth and yield. Likewise, the natural forest research and management components of the PARCE project (section 4.2) in the Koumpentoum forest reserve will furnish much needed baseline data on growth and yield of forests in the Sudanian zone as well as information on the potential incremental growth from application of certain forest management techniques.

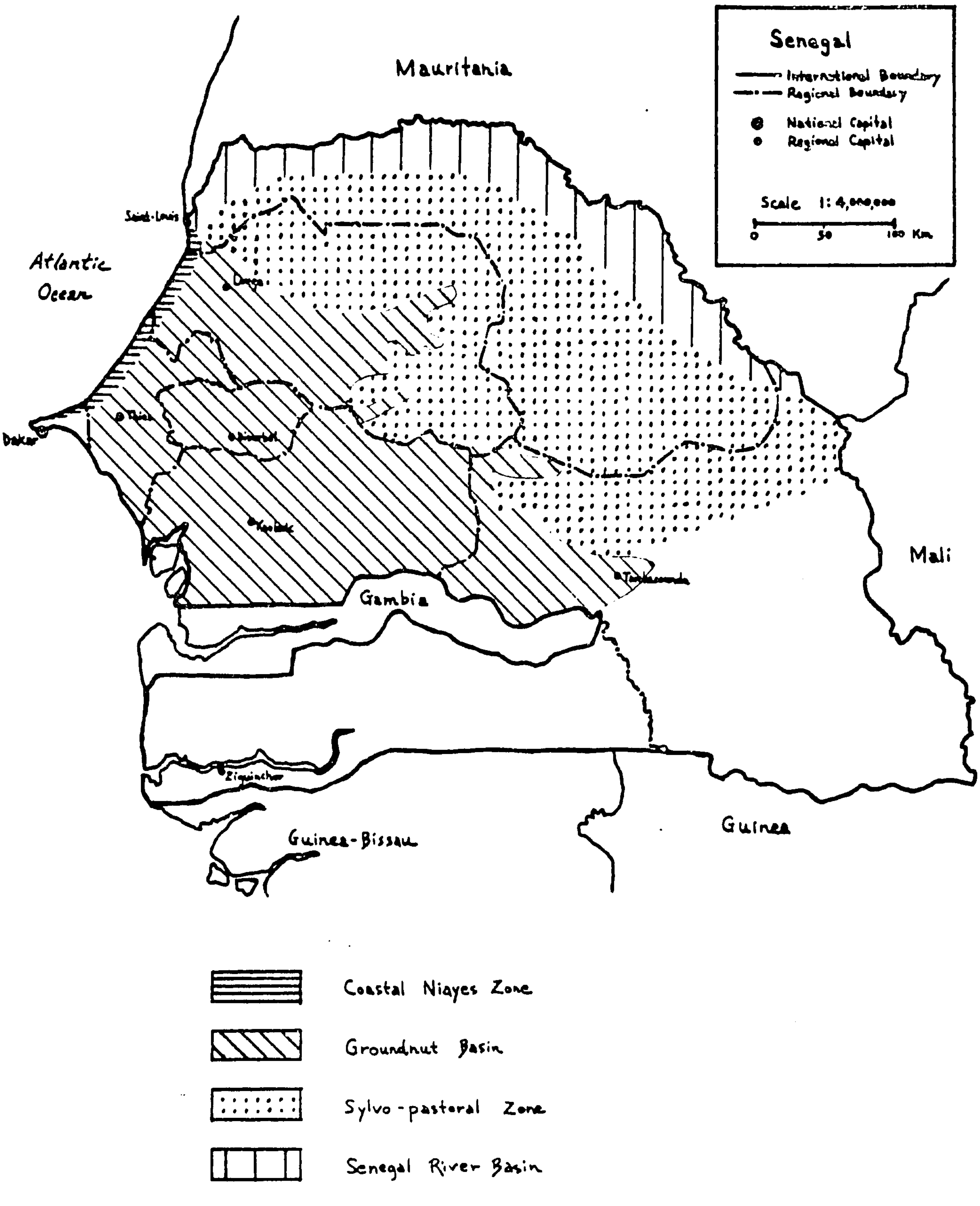
Natural forest management is a crucial issue in the entire Sahel Region and will be discussed more fully in section 10.6.

PART B

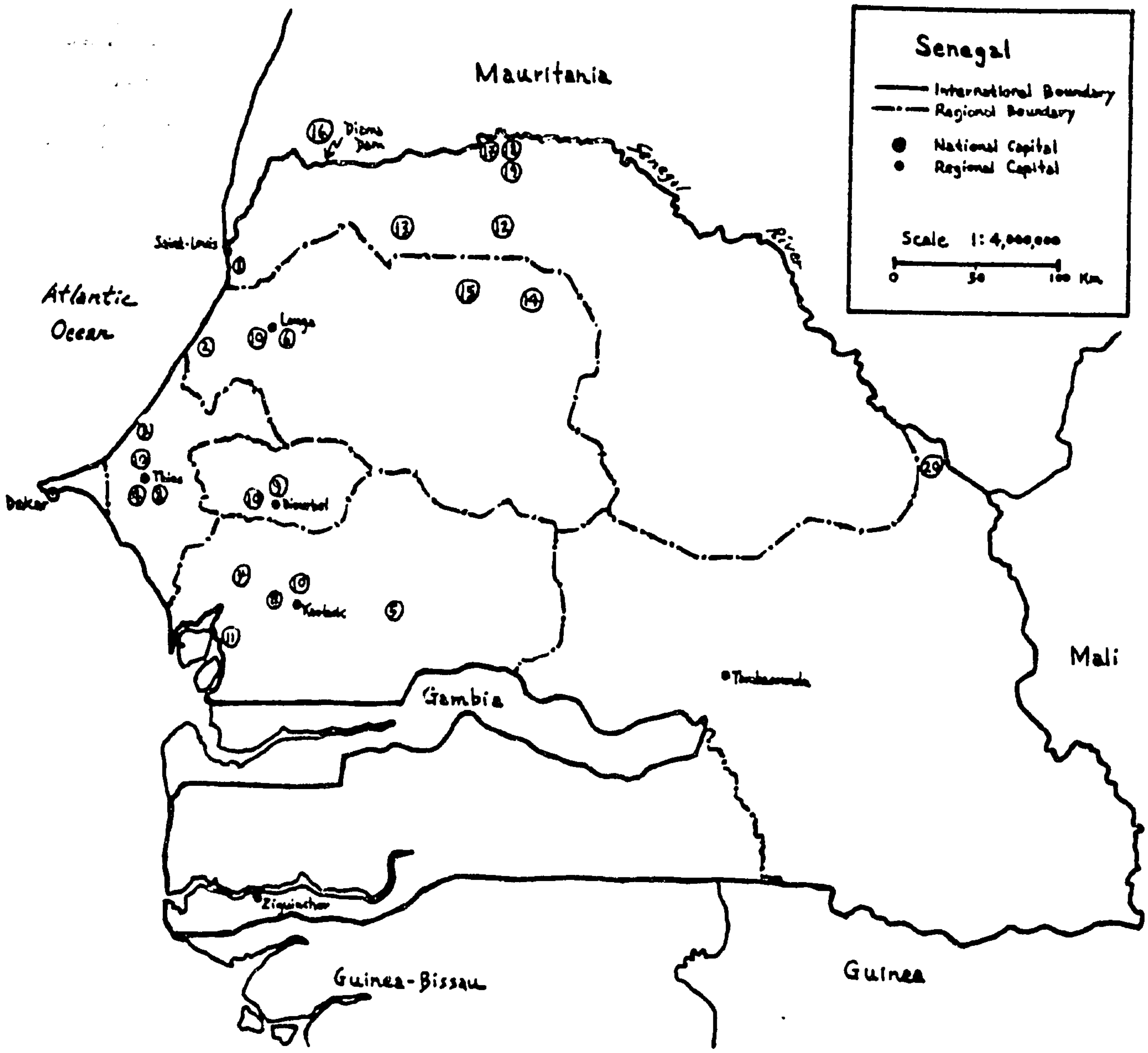
DESCRIPTION OF PROJECTS

(please refer to Map 3 and Map 4
for the approximate locations of
the major reforestation zones
and project centers)

MAP 3. MAJOR REFORESTATION ZONES.



MAP 4. APPROXIMATE LOCATIONS OF PROJECT CENTERS.



1	Gandiol Dune Stabilization	11	Cashew Production (PASA)
2	FAO Dune Stabilization	12	Mbiddi Experimental Center
3	PL-480 Dune Stabilization	13	Reforestation & Mgt of Sylvo-pastoral Zone
4	Senegal Fuelwood Production (PARFOB)	14	Lagbar Integrated Community Development
5	Reforestation in the "Center-East" (PARCE)	15	SODESP
6	Louga Community Reforestation	16	OMVS
7	Community Reforestation in Groundnut Basin (PRECOBA)	17	Nianga Irrigated Plantation Trials
8*	Africare Community Woodlots	18	Podor Gonakié Restoration
9	Diourbel Village Reforestation	19	Podor Gum Arabic Plantations
10*	SODEVA	20	Bakel Community Reforestation

* project situated in more than one administrative Region

3. COASTAL "NIAYES" ZONE

The "niayes" zone, located inland from the coastal dunes that extend from Dakar to Saint-Louis, is an important food-producing area. Owing to a very shallow, non-saline water table (averaging one to four meters below the ground surface), the "niayes" provide fertile depressions for vegetable and fruit gardening. A network of "truck marketing" connects producers with consumers along the Dakar-Thies axis. However, the "niayes" are facing the danger of dune encroachment caused by the prevailing "alizé" winds that originate from the north-northwest.

Efforts to stabilize marine dunes by planting the filao (*Casuarina equisetifolia*) were among the earliest forms of reforestation in Senegal; successful planting trials began as early as 1908. The French agronomist Etesse (1918) expressed hope that one day the entire 180 kilometers of the "Grande Côte" between Dakar and Saint-Louis would be protected with a band of planted filao. His hope has recently been fulfilled.

Most of the recent work has been carried out within the framework of the three projects discussed next. Earlier plantings took place during the 1940s and 1950s in the Cap Vert and Thies Regions; roughly 20 kilometers of coastal dunes were "fixed." In addition, the municipality of Dakar financed about five kilometers of filao plantings in 1980 in the area between Malika and Guedia Ouaye and around Lake Retba, located northeast of the capital.

While planting a 200-300 meter band of *Casuarina* represents the first defense against shifting dunes, sandbreaks and other plantings in the "niayes" zone are necessary to ensure protection of garden plots, fields, and small lakes.

3.1 Gandiol Dune Stabilization

This is the northernmost coastal project, Gandiol being situated just south of Saint-Louis (the first Senegalese capital). The project began in 1979 with 50 million FCFA from earmarked funds generated through the sale of Canadian wheat (see FCFA in the list of acronyms for currency exchange rates). The Canadian International Development Agency (CIDA) has provided subsequent financing. During the period 1979 to 1982, approximately 32.5 kilometers of filao were planted in a 200-meter wide band that extends southward from Gandiol. This represents 650 hectares of *Casuarina* plantation. Panels of interwoven nguer (*Guiera senegalensis*) branches were produced near Rao and used to protect the planted seedlings. The techniques employed were modeled after those of the FAO project discussed below.

3.2 FAO Dune Stabilization and Reforestation

The project is located about midway between Saint-Louis and Dakar. It started in 1975 with UNDP (146 million FCFA), BNE (National Budget: 215 million FCFA), and WFP support. There are three principal components (Andéké-Lengui and Ndiaye 1983):

* marine dune stabilization;
* protection of "niayes" gardening zone
* regeneration of "dior" soils (continental dunes).

A cross-section of the coastal area may be depicted as follows (FAO 1982):

Ocean______________________3-5 kilometers______________Interior___

beach	white marine dunes	yellow or pink dunes "semi-fixed"	"niayes"	red continental dunes, "fixed" with *Acacia* and *Cenchrus*

3.21 Marine dune stabilization. The FAO project serves as a prototype for other dune stabilization efforts in Senegal. Between 1975 and 1982, over 67 kilometers of the coastline were protected with filao plantings by the project.

In marine dune stabilization, the first step is to install the "contre-dune" 60 to 70 meters interior and parallel to the high tide mark. The "contre-dune" is constructed of large panels (one by three meters) of interwoven nguer branches; the panels are attached with wire to piquets of *Euphorbia balsamifera* spaced at 1.5-meter intervals. The "contre-dune" is the first check against wind-blown sand. The 200-meter wide band of plantation starts about 20 meters interior to the "contre-dune." Rows of trees are planted at a spacing of three by two meters (2 meters between rows, rows parallel to "contre dune").

To protect the filao seedlings, lines of small panels of nguer (one-half by three meters, unit cost of 100 FCFA) are staked out in a southwest-northeast orientation, perpendicular to the "alizé" winds. On relatively flat terrain (slopes of five percent or less), the nguer "sandbreaks" can be placed every 20 to 25 meters. On slopes exceeding

10 percent, a crisscross system of sandbreak lines should be used with the spacing between lines reduced according to the severity of the slope. The young seedlings require this protection from shifting sand for a six-month period, afterwards the panels and piquets can be removed and used elsewhere (FAO 1981b).

Two other methods of protection have been used on an experimental basis. The first is an acrylic mesh that comes in a roll of 1.5 by 500 meters in three mesh sizes: 2.5, 3, and 5 millimeters. The roll must be cut down to the appropriate dimensions for the "contre-dune" and the sandbreak panels. As in the case of the nguer panels, about 10 centimeters of the mesh should be anchored in the sand. The costs, on a per hectare basis, of nguer panels and acrylic mesh are given below:

	"contre-dune"	*"sandbreaks"*	*total FCFA/ha*
nguer panels	25,500	66,300	91,800
acrylic mesh (2.5x2.5 mm)	15,900	54,000	69,900

Despite its higher cost, the benefits of local employment generated by the protection of nguer panels must be considered.

A second alternative approach is the use of "texand"--an acrylic fiber that can be staked down in a web-like fashion to hold sand in place. This method works well on slopes and costs about as much as the nguer panels, although transport costs for the less-bulky "texand" would be reduced (FAO 1983).

An important treatment that favors the rapid growth of filao seedlings is the inoculation of the plants with *Rhyzobium* bacteria that can fix atmospheric nitrogen. These bacteria are obtained from root nodules of older filao trees and can be utilized in two ways. The first method is to crush the nodules, then conserve the rhyzobia in a dry or moist gel that can later be directly applied to seedlings. The more commonly used technique is to crush the nodules and soak them in water for four to five days. This mixture is used in watering the seedlings when they are 8 to 10 centimeters tall. After two weeks, small nodules should appear on the secondary roots of the plants.

Establishment costs for filao are on the order of 250,000 to 300,000 FCFA per hectare depending on the type of protection used. Survival of these filao plantations has been generally very good; rates of 80 percent or better have been recorded. Areas of significant seedling mortality--as in the 1975 plantations that received neither inoculation nor protection--are usually replanted.

3.22 Protection of "niayes". Whereas filao plantings indirectly protect the "niayes" by stabilizing coastal dune movements, the second component of the project aims to provide direct protection to this valuable area through the establishment of planted windbreaks. By the end of 1982, 197.5 kilometers of *Eucalyptus camaldulensis* and 200 kilometers of *Anacardium occidentale* have been planted around fields and gardens. Costs varied between 75,000 and 125,000 FCFA per kilometer of windbreak.

In addition, blocks of plantations have been established in some areas, such as the Australian acacias and eucalypts planted on the yellow intermediate dunes. During site visits in March 1983, the *E.*

camaldulensis appeared stunted on elevated areas (e.g., planted windbreaks on ridges of dunes). In depressions, this species grew well due to the high water table. In one 1978 plantation block, the most vigorous five-year old trees were approaching 10 meters in height and 20 centimeters in diameter.

3.23 **Regeneration of "dior" soils.** Through 1982, some 2,600 hectares of infertile "dior" soils--mainly red continental dunes of older genesis than white marine dunes--have been planted with trees at spacings of ten by ten meters to allow for intercropping. The species included: *Acacia albida*, *A. tortillis*, *A. holocericea*, *A. astregens*, *Prosopis juliflora*, *P. africana*, *Balanites aegyptiaca*, and *Poupartia birrea*. Survival of these plantings has been highly variable and is contingent on proper protection and maintenance of the trees after planting. The cost of establishing this type of plantation is estimated to range from 50,000 to 75,000 FCFA per hectare (FAO 1981b).

3.3 PL-480 Dune Stabilization

This project, concentrated along the Kayar-Mboro axis, links dune stabilization efforts near Lake Retba with the FAO efforts further north along the "Grande Côte." Funding was made available by PL-480 Title III legislation that allows commodity payments in local currency--for the purchase of U.S. rice, in this case--to be diverted to earmarked development projects. In theory, this creates the dual benefit of supporting development projects in need of financing while generating savings in foreign exchange for Senegal. However, less than one-half of the projected funding has reached the project coffers. One major reason is the weak competitiveness of the higher-quality, but higher-priced, U.S. rice against other rice, notably of Asian origin, in the Senegalese marketplace.

At the end of 1982, a 55-kilometer stretch of the coast, from about 10 kilometers south of Kayar to 10 kilometers north of Mboro, had been planted with *Casuarina*. In 1981, filaos were planted at 2.5 by 2.5 meters in a 200-meter wide band; approximately 1,000,000 seedlings were used and a total distance of 20 kilometers covered, starting from the extreme north and the extreme south of the project zone. In 1982, the two previously planted areas were connected by planting the remaining 35-kilometer area with a 300-meter wide band of filaos. For the two years combined, an estimated 3,000,000 trees were used to protect 1,400 hectares of dunes and to establish 150 hectares of plantations around Lake Tanna.

For the 1982 season, the project utilized a dozen "volantes" nurseries, temporary set-ups to produce filao seedlings employing the more common inoculation technique described in the FAO project. Innoculated with *Rhyzobium* bacteria, seedlings can reach the desired outplanting height of 20 centimeters in two months. Most of the labor--an average of 250 workers in 1982--came from the small villages of nomadic Peul herders who occupy the coastal areas for a portion of the year. Before the project commenced, these villagers demonstrated their awareness of the need for conservation measures by planting a cactus that resembles the prickly pear on the dunes.

The project manager, a SWF forester, decided to use interwoven nguer panels exclusively in the project to stimulate additional local employment. Access paths from the villages to the ocean were integrated into the design of the plantation blocks. The cost of plantation establishment was 220,000 to 250,000 FCFA per hectare (Niang, M. 1982).

The survival of the 1981 plantations was excellent, estimated at 80 to 90 percent based on site visits. Growth was superior in micro-depressions, where some trees had already attained a height of four meters only 15 months after outplanting. As the site visits occurred in October 1982, it was too early to generalize on the survival of the 1982 plantations.

An interesting experiment being conducted by the project is the establishment of filao plantation during the dry season. This is an attempt to bypass the labor constraints during the short rainy season (July to September) when labor requirements for agriculture and forestry coincide. Because of the coastal location, seedlings can benefit from two sources of moisture other than rainfall--dewdrops and shallow groundwater--thus dry-season plantations may be feasible.

4. LARGE-SCALE FUELWOOD PRODUCTION

4.1 Senegal Fuelwood Production (PARFOB)

Funding for Phase I of this project was from an AID grant of $3.1 million (806 million FCFA) and Senegalese counterpart funds projected at 171 million FCFA for salaries and vehicles. The objective was to establish 3,000 hectares of fast-growing tree species (mainly *Eucalyptus camaldulensis*) during four planting seasons (1980 to 1983 inclusive) at the Bandia Forest. This tract is located some 60 kilometers from Dakar and had been previously "managed' on a 20-year coppice rotation for fuelwood in the predominate *Acacia seyal* forest type. It was hoped that, once operational, the project would meet six percent of the fuelwood demand of Dakar. This pilot effort would provide training for SWF personnel in large-scale fuelwood production and would serve as a replicable model that could be introduced elsewhere.

However, the Project Paper (USAID 1979) proved to be totally erroneous with regard to two major assumptions:

* annual rainfall registered at Mbour (located southwest of Bandia on the coast) averaged 739 millimeters during the period 1931 to 1960; this was assumed to be representative of the project zone;

* production rates for *E. camaldulensis* were assumed to be on the order of 10 to 15 cubic meters per hectare per year "based on the CNRF trials at Bandia."

During the three rainy seasons from 1980 to 1982, the Bandia plantation site averaged 373 millimeters per year of rainfall. In 1983, the rainfall level plummeted to 238 millimeters (Jones 1984). The dubious nature of the yields assumed in the Project Paper was signaled at an early stage by a consultant (Guigonis 1979), who revised the estimates to seven cubic meters per hectare per year for *E. camaldulensis* and 4.5 for *Azadirachta indica*.

In 1981, six-year old *E. camaldulensis* of several provenances were harvested on an experimental plot at the CNRF Bandia station (seven kilometers south of the PARFOB nursery). The station had an average annual rainfall of 433 millimeters for the six-year period and the yields varied from a low of 1.5 (provenance 993-94/CTFT) to a maximum of 4.4 cubic meters per hectare per year (provenance 979-87/CTFT) (Bailly 1983). The principal provenance used in the PARFOB plantations--8411/FTB native to Derby, Australia--was not among the 31 provenances of *E. camaldulensis* tested by CNRF at the Bandia research station. This provenance was planted in 1968 at the Mbao station, a coastal site near Dakar with high water table and low evapotranspiration, with a resulting growth rate of 12 cubic meters per hectare per year (Table 8). Some of the important interactions between site characteristics and the physiological nature of *E. camaldulensis* have already been discussed in section 2.31.

Following the rule of thumb that operational plantations seldom achieve one-half of the recorded yield from well-manicured research plots, the Phase I evaluation team, after site visits in January and February 1983, scaled down the estimated production rate to 1.5 cubic meters per hectare per year. Largely because of the huge discrepancies between project design assumptions and on-the-ground realities, Phase I was determined to be economically infeasible and the evaluation team recommended not to pursue a Phase II of the project.

Plantation accomplishments through 1982 are presented in Table 9.

Table 9

PARFOB plantation hectarage by year and species.

Year	Annual rainfall (mm)	*Eucalyptus camaldulensis*	*Prosopis juliflora*	neem	*Cassia* siamia*	*Melaleuca leucadendron*	Total
1980	320	150					150
1981	355	617	12		26		655
1982	445	592	114	30	7	7	750
Average	733 Total	1,359	126	30	33	7	1,555

Source: Freeman 1983

* planted in association with eucalyptus

Mortality rates, based on a seven to eight percent sample, ranged from 3-40 percent (the severest rates reflecting the 1980 plantations located on lateritic hardpan) for *E. camaldulensis* and 5-18 percent for *Prosopis juliflora*. Field observations readily confirm the superiority of *Prosopis* in terms of drought and termite resistance. The direct or operational costs of one hectare of plantation were calculated at $808 or approximately 220,000 FCFA at 1981 exchange rates (Freeman 1983).

Soil survey data, provided by soil scientists on detail from the U.S. Soil Conservation Service, were not available until the site selection process for the 1981 campaign. As a result, some eucalypts were planted in 1980 on lateritic sites with hardpans situated between one and two meters below ground surface.

Site preparation, except for the initial removal of the natural *Acacia seyal* forests by charcoal-making cooperatives, is dependent on mechanization. Mechanical site preparation is both expensive (equipment operation, exclusive of operator wages, accounted for 26 percent of the direct costs) and troublesome (numerous problems with equipment breakdowns, procurement of parts, and lack of maintenance and repair expertise).

The onerous site preparation involves several operations. After the woody material is removed to be converted to charcoal, the site is brush-raked and windrowed by two Caterpillar D-6 crawler tractors. Next, the larger D-7 levels the termite hills, fills in holes, and knocks down and windrows small baobab trees (*Adansonia digitata*). Subsoiling to a 50-60 centimeter depth is then performed by a three-tooth ripper mounted to one of the Caterpillars. The disc-harrowing operation is carried out by Massy-Ferguson wheeled tractors in a direction perpendicular to the subsoiling. Finally, one-tooth subsoiling in two directions is accomplished by the Massy-Fergusons to a depth of 60 centimeters, the intersections of the subsoiling lines indicating the planting spots. In theory, the initial plantation spacing should be four by four meters. The actual spacing has been widened to about 4.3 by 4.3 meters to avoid damaging trees in the subsequent mechanized weedings.

PARFOB has other important components. The project funded certain research activities by CNRF, which have been described in section 2.31. In addition, the Bandia nursery--perhaps the largest facility of its kind in Senegal--has provided seedlings to other projects as well as to some Regional Inspectorates of the SWF. This included a joint venture with SODEVA (section 5.5 discusses their reforestation activities) in 1982 to establish small woodlots, ranging from one-half to one hectare, in seven villages near the periphery of the Bandia Forest.

Because of the infrastructure and technical expertise that have been developed, there is a favorable argument for evolving the nursery into a regional facility beyond the project life of PARFOB. This concept would be predicated, in part, on obtaining authority from the SWF to sell seedlings--in particular fruit trees that require more nursery time and care (e.g., grafting)--in order to defray a portion of the recurrent costs. Attaching a market value to seedlings, which have traditionally been distributed without charge, may also act as an incentive for better protection and maintenance of planted trees.

4.2 Reforestation in the "Center-East" (PARCE)

This project is an offshoot of a pilot effort that began in 1979 with the objective of establishing 700 hectares of *Eucalyptus camaldulensis* in the Kaffrine Forest Reserve. The original sources of financing were the FAC (75 million FCFA), the CCCE (65 million FCFA), and Senegalese counterpart funds (10 million FCFA).

The "center-east" area is one of fuelwood surplus owing to relatively low human densities, averaging 21 inhabitants per square kilometer in the western part of the project zone and only nine per square kilometer in the eastern part. This area, located 200 to 350 kilometers east of Dakar, is a major source of fuelwood for the capital as well as congested portions of the Groundnut Basin. The vegetative cover is a transitional mix between Sudanian and Sahelian flora, hence, representative of both the Sudano-Sahelian and the Sudanian zones. The annual growth rate of the forest vegetation is estimated at one cubic meter per hectare. Average annual rainfall generally exceeds 700 millimeters, although approximately 600 millimeters were recorded in 1981 and 500 in 1982, with the eastern part of the project zone receiving only 320 millimeters (Bathily 1983).

For the pilot plantation phase, an initial spacing of four by four meters was adopted; subsoiling was done by a bulldozer-drawn ripper (a switch was made in 1983 to tractor subsoiling to avoid trenching that was caused by the bulldozer tracks). The accomplishments of this phase are given in Table 10.

The SWF reached an accord with the World Bank to use the pilot project as the basis for developing a comprehensive forestry project. The World Bank orchestrated additional funding of 3.6 billion FCFA for a five-year project that would include these components (World Bank 1981):

1. *Fuelwood plantations in forest reserves*--2,000 hectares of primarily eucalyptus plantations to be established in forest reserves in the Sine-Saloum Region; a soil survey of forest

Table 10

Eucalyptus plantations established in forest reserves with FAC/CCCE financing.

Year	Estimated Survival Rates (%)	Location and Hectarage	Comments
1979 1980 1981	42 72 63	300 ha in Kaffrine Forest Reserve	soil problems (lateritic hardpan) and poor nursery stock
1982	84	200 ha in Maka-Yap Ouest Forest Reserve	
Total		500 ha	

Source: Bathily 1983

reserves in the project zone has been completed by a team from ORSTOM to determine suitability for plantation establishment. In addition, the eucalyptus plantations established during the pilot phase will continue to receive maintenance.

2. *Rural plantations*--3,000 hectares of mostly eucalyptus and neem trees to be established in the Sine-Saloum and Senegal Oriental Regions: 1,500 hectares of family plantations with the extension assistance of SODEVA, STN, and SODEFITEX and 1,500 of medium-scale plantations through Rural Communities (see section 5.1 for an elaboration of the Rural Community concept).

3. *Natural forest management*--design and implement research on various management techniques to be applied in the 10,200-hectare

Koumpentoum Forest Reserve, located in the Sine-Saloum and Senegal Oriental Regions.

4. *Applied research*--in collaboration with CNRF, carry out research on species selection, tree improvement, site preparation, plantation establishment, and natural forest management techniques.
5. *Training center*--establish a center in Kahone (near Kaolack) to provide short courses to "retrain" in-service forestry personnel in skills such as extension work.
6. *Planning, monitoring, and studies*--a variety of activities under the umbrella of institution building: strengthening of the Planning Division of the SWF, studies on the implications of pricing policies on fuelwood, and research on alternative approaches to forestry interventions in the rural milieu.

Of particular importance are the components of rural plantations and natural forest management. The pivotal role that rural populations must play in producing fuelwood for both rural and urban consumption is well recognized in the Master Plan for Forestry Development; this point was discussed in sections 2.24 and 2.25. Community and village plantations have increased from 15 percent of the total area planted in 1977 to 55 percent of the total plantation area in 1982 (Table 3).

A two-pronged approach to rural reforestation has been adopted by PARCE. The establishment of family nurseries and plantations--with the necessary extension support of parapublic rural development agencies--is geared toward fulfilling subsistent wood needs in the rural sector. On the other hand, the establishment of medium-sized plantations through Rural Communities should, in theory, produce surplus fuelwood and construction poles that can be marketed to urban or densely-populated areas.

In the case of working with a Rural Community, a signed agreement would define certain terms. In general, the Rural Community is expected to pay 35 FCFA per seedling (the break-even price established by SODEVA); payment may be immediate or at the time of the first wood harvest. If the plantation is large enough to warrant tractor subsoiling (five hectares or more), the equipment will be provided by the project with approximately one-fifth of future harvest revenues retained to cover the costs. Subsoiling by means of animal traction is preferred and encouraged where possible.

Unfortunately, natural forests in the Sahel have often been regarded as "useless brush." Today, this view is changing. The Koumpentoum Forest Reserve represents an immense laboratory where certain management options can be tested to ascertain their effects on natural regeneration and growth. These options include: (1) protective measures against encroachments, brush fires and overgrazing; (2) intermediate and regeneration cuts; and (3) complementary seeding, harrowing and weeding. By appropriately employing management techniques, it is hoped that the natural forest yield can be doubled to two cubic meters per hectare and provide a product mix of 10 percent timber, 10 percent construction poles and 80 percent fuelwood.

For *E. camaldulensis*, annual production estimates are six cubic meters per hectare in state-managed plantations and four cubic meters per hectare in rural plantations. A 6-5-5 coppice rotation is envisioned, with replanting after 16 years. The end use is assumed to be 80 percent fuelwood and 20 percent poles; 25 to 50 percent of the rural production is expected to be sold to generate revenues for repayment of establishment costs and for other investments.

5. GROUNDNUT BASIN

The so-called Groundnut Basin is one of the oldest areas of cash-crop agriculture in West Africa. Groundnuts and their products remain the most important export of Senegal, despite falling world prices.

Since the turn of the century, expansion of the Groundnut Basin has proceeded steadily eastward. Today, it encompasses the administrative regions of Thies, Sine-Saloum, Diourbel and Louga. The two major ethnic groups are the Wolof, who make up about two-thirds of the Basin population, and the Serer, concentrated in the southwestern portion of the Basin. The Serer, one of the oldest sedentary farming groups in West Africa, have developed an intricate and stable agro-sylvo-pastoral system utilizing the *Acacia albida* tree, cattle manure and fallowing (Pelissier 1966). However, overpopulation, resulting in densities exceeding 100 inhabitants per square kilometer, has wreaked havoc on this system; fallow lands are virtually absent and fertility and yields are declining. Cash-cropping, in the form of individual peanut plots, has intensified at the expense of communally cultivated food fields--millet, maize and "niébé" beans (pigeon peas)--in both Wolof and Serer areas (USAID 1981).

While the "Terres Neuves" resettlement scheme, funded by the World Bank, in Eastern Senegal may alleviate a small amount of the population pressure in the Groundnut Basin, two worsening and related problems--environmental degradation and fuelwood deficit--demand immediate attention if a "dust bowl" scenario is to be averted.

The two projects discussed in the previous section are technically located in the Groundnut Basin: PARFOB in the extreme western portion and PARCE in the eastern end. However, their main orientation is toward large-scale fuelwood production to help meet the urban demand. In most of the Groundnut Basin, land and labor constraints preclude large-scale plantation efforts. This section, therefore, examines projects that attempt to initiate reforestation activities within the given constraints of the Basin.

For want of more precise terminology, these projects may be considered under the rubric of *social forestry*. The recent emphasis on social forestry is a response to the shortcomings of prior attempts at forestry development: Failure in getting the benefits to the target population and autocratic style of management are just two examples. Social forestry is people-oriented, characterized by small scale, local control and decentralized benefits (Burch 1982); it includes approaches that are directed at individuals or families as well as communities (Hoskins 1982).

In the Sahel, efforts in social forestry have frequently been unsuccessful. One reason is that although extension is the key in working with farmers and herders, this aspect is sorely lacking in the education and training of foresters. Suppressive police action, to enforce regulations enacted during the colonial era (e.g., forest reserves and "protected" species lists), is still a hallmark of Sahelian forestry (Thomson 1981). Senegal has recently initiated a variety of social forestry projects, many of which are located in the Groundnut Basin. While some of these projects have not yet found the essential mark--participatory and integrated resource management--others are getting closer to developing a model that meaningfully integrates local populations in reforestation activities.

5.1 Community Reforestation in the Groundnut Basin (PRECOBA)

PRECOBA operates in the southwestern part of the Groundnut Basin, roughly situated between Mbour and Kaolack, with Fatick serving as the project center. This covers an extensive area; average rainfall between 1971 and 1981 ranged from 477 millimeters per year in the north (Bambey) to 757 in the south (Nioro du Rip).

The project is executed by the FAO, with funding from Finland (195 million FCFA) and the Government of Senegal (30 million FCFA). The methodology utilized by the project, which began in 1981, is one that combines studies, implementation and evaluation, with training as a major component. The guiding philosophy behind PRECOBA is reflected in the following statement (PRECOBA 1982a):

> "La cible du projet n'est pas un espace donné, mais une population. . . Parce qu'une société humaine ne peut ètre considérée comme un facteur ecologique fixe, mais plutôt comme une structure complex qui réagit et evolue en fonction des actions introduites dans son environnement. . .
>
> ["The target of the project is not a given zone, but a population. . . Because a human society cannot be considered

> as a fixed ecological factor, but rather as a complex structure that reacts and evolves as a function of actions introduced in its environment. . ."]

During the first year of the project, studies were conducted, including: (1) a sociological survey to determine local perceptions and needs concerning reforestation and to generate local participation in the project. Villagers were "pleasantly surprised" that their opinions were sought. Findings, such as desired tree species, were incorporated into the execution of the project (PRECOBA 1982b, c); (2) a comparative study of customary and legal systems of tree tenure, especially with regard to trees in fields and fruit trees; and (3) a study of the sylvicultural requirements and production rates of desired tree species (PRECOBA 1982a).

The project works closely with Rural Communities, which are new administrative entities created by Public Law No. 72-02 of February 1, 1972. The Rural Community is the nucleus of efforts at administrative reform and decentralization. Each Rural Community comprises several villages and has an elected President and Council who hold certain powers of fiscal, budgetary and resource allocation. The President of the Rural Community Council acts as the superintendent of national domain lands (97% of all lands in Senegal); he allocates land-use rights and arbitrates land tenure disputes. However, tree crops are not within the jurisdiction of the Council (Fell, 1978). PRECOBA is designed so that external funding will keep the project solvent until the first woodlot harvests (circa 1989), from which time the Rural Communities will assume financing and management of the woodlots.

Ordinarily, training is given to nurserymen and "chefs de chantier" (crew foremen) selected by each Rural Community engaged in the project. Locally available materials and technologies are emphasized; for example, horse-drawn carts for the transport of seedlings and large hand-dug plantation holes (90x40x60 cm deep) are adopted techniques. There are two major reforestation components. The first is the creation of plantation blocks--*E. camaldulensis* and other species at four by four meters--of approximately 10 hectares per Rural Community. The second is the promotion of *Acacia albida* in fields, either by interplanting the kad tree at ten by ten meters or by "assisting" natural regeneration--selecting and favoring the principal stem where clumps of naturally-regenerated kad exist (e.g., in the vicinity of Fimela, located in the southern part of the project zone).

In 1982, these two components were initiated. Furthermore, understocked portions of an extensive stand of ronier palm (*Borassus aethiopum*) were seeded at a spacing of 10 by 10 meters. In addition to reforestation activity, PRECOBA has a "Ban ak suuf" component that works with local women to conserve fuelwood by using improved cookstoves. Table 11 summarizes the reforestation accomplishments of 1982 and the planned program for 1983.

The direct costs of plantations are estimated to be 150,000 FCFA per hectare, 85 percent of which go to labor. Workers are paid in cash or food from the WFP depending on the specific tasks performed. For trees planted in 1982, the year-end survival rates were 82 percent for the plantation blocks and for *A. albida*: 98 percent survival on "dior" (sandy) soils and 88 percent on "deck" (clayey) soils (Jensen 1983).

Table 11

PRECOBA accomplishments for 1982 and targets for 1983.

Type	1982 Accomplishments (in hectares)	1983 Targets
Plantation blocks	90	220
Acacia albida:		
interplanting in fields	16	300
"assisting" natural regeneration	220	200
Ronier palm seeding	330	
Total	656	720

Source: Jensen 1983

An interesting experiment was conducted for "plantation en profondeur" (deep planting). Trees were planted so that the root collar was buried 30-40 centimeters below the ground level, as opposed to normal planting procedures where the root collar is at or near the surface. The rationale behind this action was two-fold: First, near ground level are high temperatures that adversely affect root growth--it is postulated that root growth slows significantly at 30 degrees Celsius and stops completely at 35-40 degrees ; second, the upper soil layers are the first to dry up. In theory, the seedling can be favored by positioning its root system in a cooler, moister stratum of the soil horizon. With the limited experimentation to date, this hypothesis was reinforced only for eucalypts planted at the Loul-Sessane site. There, normal planting resulted in a 58 percent year-end survival, compared to 92 percent for deep planting (sample size of 26 for each planting method, Leahy 1983).

Another interesting component of the project involves research carried out by a Peace Corps Volunteer on the yield and sylviculture of *Acacia seyal*. This species typically occurs in pure stands scattered throughout the Sahelo-Sudanian zone. An extensive stand near Nguenième offers opportunities for research on fuelwood yields of *A. seyal* and on regeneration techniques--coppicing (size of coppice stool and number of shoots as variables), natural seeding, and prescribed burning as a management tool to enhance regeneration.

5.2 Louga Community Reforestation

This project is funded for a three-year duration by Sweden, through the FAO, in the amount of 396 million FCFA with a Senegalese counterpart contribution of 173 million FCFA. The conceptualization of the project stemmed, in part, from a study commissioned by the FAO on forestry for local community development in Senegal (Hoskins and Guigonis 1979).

In the Louga Region, two distinct zones exist. The Louga zone, situated at the northern limit of the Groundnut Basin, is becoming marginal for cultivation due to a series of years of deficit rainfall (well below 200 millimeters per year). Efforts in this zone will be directed through the Rural Communities and will consist of community woodlots and enrichment of cultivated fields with trees such as *Acacia albida*. Targetted for 1983, the first operational year of the project, were 120 hectares of community woodlots and 150 hectares of enrichment plantings and protection of natural regeneration (République du Sénégal 1983a).

The Linguère zone is composed of two areas: (1) a cultivation area in the south that resulted from the expansion of groundnut cash-cropping during 1940 to 1970 and (2) the traditional sylvo-pastoral area. In the area under groundnut cultivation, reforestation activities will be similar to those envisioned for the Louga zone. In the sylvo-pastoral area, efforts will be centered on range rehabilitation with plantings of forage tree species and gum arabic (*Acacia senegal*) (FAO 1981c). The program planned for 1983 was to establish 760 hectares of community woodlots and 200 of state-managed plantations in the Linguère zone (République du Sénégal 1983a).

5.3 Africare Community Woodlots

This project involved a grant from AID ($126,000) to Africare, an American private voluntary organization (PVO) that administered the project. Working with Rural Communities, who organized labor for the woodlots, the SWF established 190 hectares of community woodlots at eight locations in 1980 and 1981 (Table 12). Woodlot size ranged from 10 to 35 hectares. Establishment costs were approximately $770 per hectare, which included an equivalent of $50 of "food for work" from the WFP.

Site visits were made to Tchailé (January 1983) and Noto (February 1983) with the SWF Regional Inspector of Thies. At the Tchailé site, *Eucalyptus camaldulensis* was planted in August 1981 at a spacing of three by three meters. The plantation was established on a fallowed field that was selected by the Rural Community. A SWF tractor performed the subsoiling and weeding operations. Two weedings followed the

Table 12

Community woodlots established in Africare project.

Region	Location	1980	1981	Total
		-------(in hectares)---------		
Kaolack	Sakhao	20	35	55
	Gamboul	20		20
	Mbadakhoune	20	20	40
	Ndiene Lagante	10	15	25
	Nbill		10	10
Thies	Noto	10		10
	Keur Matar		10	10
	Tchailé		20	20
Total		80	110	190

Source: Weber 1981a

outplanting in 1981; only one weeding, a partial one, took place in 1982 (Voyni 1983). Protection included a "guardian" who patrols the plantation area and a live fence of *Euphorbia balsamifera*, one side of which was carelessly crushed by the tractor while making turns during the weeding operation. Survival of the eucalypts was excellent in micro-depressions (90 percent or better) and some trees were five meters in height. However, mortality occurred in a clump-like pattern, especially on slightly elevated sites. Overall survival was estimated at 60 to 70 percent.

Woodlots of this considerable size present formidable problems with regard to weeding, which should be done as early as possible during the rainy season to mitigate the reduction of soil moisture by herbaceous plants. Because this period coincides with peak labor demands in cultivated fields, it is difficult to mobilize the labor required for manual weeding of the plantation. If mechanized weeding is institutionalized, then local participation would occur only during the planting operation. This situation risks creating the perception that villagers are exploited as "cheap labor" in a government project.

5.4 Diourbel Village Reforestation

The administrative structure of this project is similar to the project discussed above. An Operation Program Grant (OPG) in the amount of $211,344 was given by AID to Africare in 1980. The project operates through the Diourbel Regional Inspectorate of the SWF, with Senegalese forestry agents and Peace Corps Volunteers performing extension work with villagers. Viewed as a pilot effort, the original time framework was two years: 1981 and 1982. However, this phase was extended to 1983, utilizing unexpended funds from the first two years ($40,000) and an additional funding commitment of $21,000 from the Title III program.

The intervention level of this project is the village, as opposed to the three previous projects in which the focus is the Rural Community. The initial project design envisioned "individual woodlots at the rate of 9 hectares or 5,625 trees per year in each of 40 participating villages (8 in the first year, 32 in the second)" (USAID 1980). The Africare/SWF agreement recognized two components: (1) village woodlot establishment in the Bambey Department and (2) *Acacia albida* (kad) interplanting in millet and peanut fields in the Diourbel Department.

The 1981 village woodlots were in the form of a 32-hectare plantation (eight hectares per village) on state land near Ndiemane, six to 10 kilometers from the four villages that provided labor. The plantation was a complete failure due to late planting, inferior nursery stocks, and lack of protection and maintenance. The *Acacia albida* planted in 1981 were unprotected and estimated in 1983 to be surviving at rates of 5-10 percent.

The unrealistic nature of nine-hectare village woodlots in the Diourbel Region is obvious given the situation of extreme land scarcity. In the Region as a whole, population density exceeds 100 inhabitants per square kilometer and the ratio of arable land per person is a scant 0.75 hectare (République du Sénégal 1981). An evaluation carried out after the 1981 planting season recognized this and other design flaws and recommended to "enlarge (the) scope of project to include all forestry and conservation activities of particular interest to the local people, including food and fruit trees, shade plantations, windbreaks, protection of natural vegetation, soil conservation, etc." (Weber 1981b). This led to a revised 1982 program that included the following activities:

* establishment of small woodlots (usually one hectare or less) located near the villages;
* extension of kad interplanting into the Bambey Department;
* distribution of seedlings for planting in family compounds and village public places.

A second evaluation in 1983 found that although consistent extension efforts were still lacking, the project had made significant progress toward developing a replicable model of village-level reforestation (Lai 1983). Table 13 gives the rates of plantation establishment and survival for 1981 and 1982. Although precise survival figures are unavailable for individual distribution of trees, observations during site visits indicated that, in many villages, survival rates of 50 percent or greater were likely. Trees planted in family compounds, village squares, and similar areas usually benefited from some form of protection and incidental water disposal.

Thus far, *Prosopis juliflora* has proven to be the most resistant species against water salinity in nurseries and against drought and termites in woodlots. The *Prosopis* planted in the Bambey Department in 1982 had over 50 percent survival. The experience with *Eucalyptus camaldulensis* indicates that it is an inappropriate species for most of the Diourbel Region. For example, only one out of four eucalypts planted in 1982 survived. The average rainfall in the Region--420 millimeters in 1981 and 400 in 1982--is below the minimum level of 500 millimeters per year that is recommended for *E. camaldulensis* in rural plantations. *E. microtheca*--by virtue of trials at the CNRF stations in Bambey that resulted in a growth rate of 3.4 cubic meters per hectare per year (as opposed to 2.2 for the best provenance of *E. camaldulensis*)--may be a better species selection for the compact, clayey "deck dur" soils found in depressions ("bas-fonds") where many woodlots are located (Hamel and Bailly 1983).

Village nurseries are an integral component of this project as well as most social forestry initiatives. In the past two years of the

Table 13

Diourbel village reforestation:
rates of plantation establishment and survival
in 1981 and 1982.

Department	Activity	1981				1982			
		Number	Area (ha)	No. Trees	Survival (%)	Number	Area (ha)	No. Trees	Survival (%)
Bambey	Village Woodlot	4	32.0	19,903	0	8	4.1	2,240	44
	Kad Plantation					22	16.0	1,600	65*
Diourbel	Village Woodlot	1	1.5	900	0	11	7.4	4,455	29
	Kad Plantation	?	36.0	3,600	5-10*	70	62.0	6,200	25*

Source: Lal 1983

* estimates

project, seedling production increased from 33,000 in 20 villages in 1982 to more than 38,000 in 35 villages in 1983. There was a trend toward growing many indigenous, multiple-use species in the nurseries; 21 different species, indigenous and exotic, were produced in the 1983 nurseries. In addition, most village nurseries had an associated vegetable garden, which provides supplementary nutrition and/or income and acts as an incentive for regularly watering the seedlings and vegetables.

The project will continue in 1984 and 1985 with funds from the Title III program, which will preclude the need for Africare as an administrative intermediary since this funding mechanism involves local currencies earmarked from Senegalese purchases of U.S. commodities (rice and sorghum). Specific recommendations were made to enhance the future performance of the project by streamlining administrative and financing procedure, moving toward greater reliance on sustainable local technologies (e.g., live and thorn-branch fencing rather than expensive barbed-wire fencing), strengthening the training and extension components, and fostering collaboration and experimentation (Lai 1983).

5.5 SODEVA

SODEVA is a parapublic rural development agency that was established in July 1968 and charged with improving agricultural production in the Groundnut Basin. The strength of SODEVA in training and extension also facilitates the effective promotion of reforestation and soil conservation as complementary actions to sustain agricultural productivity.

In reforestation, SODEVA agents work at two levels: individually with farmers and collectively with village "reforestation committees" that organize funds and labor. In addition to establishing small woodlots, SODEVA works with villagers to plant windbreaks and to interplant *Acacia albida* or to protect naturally-regenerated kad trees with thorn branches. The recent emphasis on protection of natural kad seedlings--either in groups (e.g., 10 seedlings per villager) or in bands (e.g., each villager protects kads in a 25-meter wide swath)--is a direct result of the experience with poor survival of planted kads, which lacked proper protection and maintenance (Gueye 1983).

The promotion of these activities is achieved by radio broadcasts, distribution of literature in local languages, and visits by SODEVA agents to villages. Food from the WFP is distributed to encourage forestry activities. The 1981/82 campaign is summarized in Table 14.

It is not surprising that the Sine-Saloum Region has carried out more forestry activities than the other Regions; the Sine-Saloum is blessed with the best combination of land availability and rainfall in the Groundnut Basin. In Thies and Diourbel, population density and land scarcity are the most pronounced in the Basin and rainfall is marginal for species such as *Eucalyptus camaldulensis*. The land constraint is less severe in the Louga Region, but there is inadequate rainfall for desired tree growth (Freeman 1982).

SODEVA has fostered liaisons with other projects. In 1982, SODEVA worked with PARFOB to initiate village woodlots in the area surrounding Bandia Forest and also received 33,940 eucalypts and 1,350 mangoes nursery operating expenses and to encourage farmers to protect their investment by adequately protecting and maintaining the trees they purchase and plant. In Ngodiba, SODEVA worked with village women to operate small nurseries and to sell seedlings locally (Hoskins 1979).

Starting in 1982, SODEVA experimented with this idea in the Diourbel Region, where there are two types of village-level nurseries: individual and collective. For the collectively run nursery at Gad-Affé, SODEVA instituted a policy whereby after fulfilling the seedling needs of the village, surplus seedlings could be sold to other villages or farmers. *E. camaldulensis* and *Acacia holocericea* seedlings were sold at a "symbolic" price of 10 FCFA per plant; one-year old, grafted mangoes were sold at 150 FCFA per plant. By selling 5,000 eucalypts and acacias and 1,000 mangoes, the village earned 200,000 FCFA (Ndao 1983). This type of "private sector initiative" is part of the policy actively pursued by USAID in their funding of reforestation projects in Senegal (Rifkan 1983).

5.6 Cashew Production (PASA)

The Projet Anacardier Sénégalo-Allemand (PASA) is based in Sokone, in the extreme southwestern part of the Groundnut Basin. Started in 1980, the project is financed by the Federal Republic of Germany in the amount of 650 million FCFA, with an expected counterpart contribution of 80 million FCFA.

The original objectives were to establish 5,000 hectares of cashew plantations in five years, thin 2,500 hectares of plantations established in the 1960s, and construct a cashew processing facility. Due to early indications that older plantations may not respond satisfactorily to thinning and the growing popularity of cashew trees with local farmers, the objectives have been revised to 8,000 hectares of plantation establishment and 1,000 hectares of thinning (Sall 1983, Ndiaye, I. 1983).

The cashew (*Anacardium occidentale*) is indigenous to Northern Brazil. The Portuguese introduced this species to their colonies in India and Africa. By the 16th century, the cashew was planted in Guinea-Bissau, which borders to the south of Senegal. As noted in section 2.1, the cashew was widely planted in Senegal in the 1960s as a drought-resistant, reforestation species.

Recently, interest in this species has shifted to the cashew nut. Since the creation of SODENAS, the cashew exploitation company, the producer's price for unprocessed nuts has doubled in three years, from 25 to 50 FCFA per kilogram. When the processing plant becomes operational (financing problems postponed the scheduled completion for 1983), the farmer will receive 70 FCFA for each kilogram of nuts delivered to the plant. The processing capacity is expected to be 3,000 tonnes of raw nuts per year, utilizing the Fletcher and Steward dehusking system.

The project nursery produced 200,000 seedlings in 1982 and the expected production for 1983 was between 250,000 and 300,000 seedlings. Seed selection is a high priority. The nursery site, therefore, has trials for provenances from Brazil, Benin, Mozambique and the Far East.

Other types of experimentation include fertilization trials, spacing trials and planting trials with and without removal of the polipot.

Fruiting usually begins when the tree is three years old. Flowering commonly starts sometime in December; only hermaphroditic flowers will subsequently fruit--their stamens have pointed ends whereas male flowers have stamens with knobbed ends. Optimal rainfall for the production of cashew nuts is in the range of 800 millimeters per year, the minimum level is 200. Sokone receives an average annual rainfall of 700 millimeters. The period of peak nut production for the tree is generally between the ages of 12 and 50 years, when annual yields may be 25 kilograms of nuts per tree. The initial harvest, in four-year old plantations, may be only 300 kilograms per hectare. But once the plantation reaches peak production, annual yields may exceed 2,000 kilograms per hectare. The fruit that surrounds the nut is edible--sweet but astringent--and is sometimes sold in local markets.

By the end of 1982, PASA had established a total of 5,820 hectares of cashew plantations; 1,300 in 1980, 2,200 in 1981, and 2,300 in 1982. Of the total, 5,341 hectares were Rural Community, village or individual plantations; only 479 hectares were planted with paid labor on state lands. Approximately 100 hectares of the rural plantations have been intercropped with millet, peanuts or tomatoes. Cotton intercropping is discouraged because the cotton plant is host to *Helipitis*, an insect pest of the cashew.

Overall survival rate is estimated to be near 50 percent. The main problems have been damage from brush fires and animals, especially goats and monkeys. State-managed plantations generally have higher survival, up to 90 percent, because of better protection and mechanized weeding (Behrens 1983). However, they are more expensive (estimated at 50,000 FCFA per hectare) to establish than rural plantations, where villagers provide labor without remuneration.

Approximately 500 hectares of plantations established in the 1960s have been thinned. At that time, cashews were planted with the objective of rapid reforestation, not nut production. For example, at the Patela Forest Reserve, 150 hectares were direct seeded with cashew at a spacing of three by three meters (1,100 trees per hectare). At that density, annual nut yields are only on the order of 150 kilograms per hectare. Recently, thinning was conducted by the project on 140 hectares (10 left as a control) to a residual spacing of 12 by 12 meters (65 trees per hectare) to determine if this will stimulate crown development and nut production.

Initially, the project recommended a 12 by 12 meter spacing for rural plantations. Presently, a 5 by 15 system (120 trees per hectare) is advocated. This is designed to maximize nut production while benefiting crops that are cultivated between the planted rows of trees, which act as windbreaks. Observations of cashews planted as live fences or windbreaks suggest that there is greater nut production per hectare with this spatial scheme than with a uniform and more dispersed spacing pattern (Behrens 1983).

6. SYLVO-PASTORAL ZONE

The sylvo-pastoral zone extends over the northern and central portions of Senegal, an area commonly called the Ferlo. Much of this zone is divided into sylvo-pastoral reserves, 20 units totalling 1.5 million hectares, and fauna reserves, three areas that represent 1.2 million hectares. Over 70 deep wells have been bored, about 30 to 40 kilometers from each other, in these rangelands (Fleury 1982) Nomadic Peul herders are the dominant ethnic group; cattle and goats are their livelihood. A combination of factors--recent droughts, increased numbers of livestock and agricultural expansion into parts of the traditional sylvo-pastoral zone--have caused a general degradation of the range. Areas adjacent to watering points have suffered the greatest damage due to overgrazing and trampling by cattle.

6.1 Mbiddi Experimental Center

This project is actually a merger of two earlier efforts in the Ferlo. The first, begun in 1973, established a station for research on genetic improvement and sylviculture of *Acacia senegal*, the gum arabic (see section 7.4 for a discussion of its economic importance). The second effort was initiated in 1974 to investigate forage tree species that could be used to rehabilitate the severely degraded areas around watering points.

Canadian funding, via IDRC, amounted to 148 million FCFA, with a projected counterpart funding of 56 million FCFA. Research at the Center is coordinated by CNRF.

6.11 Gum arabic. Species and provenance trials were established on 75 hectares, at an annual rate of 25 hectares during 1974-1976, for 15 provenances of *Acacia senegal* (10 from Senegal, 4 from Niger, and 1 from Chad) and 3 provenances of another gum tree, *A. laeta* (2 from Sudan and 1 from Niger). Survival has been on the order of 85 to 90 percent; rodent damage occurred in 1975 but areas of mortality were replanted.

Spacing trials demonstrated that an initial spacing of 2.5 by 2.5 meters led to intense intraspecific competition for the limited soil moisture. Rainfall in the area is low and erratic. Since the inception of the project, the maximum and minimum annual rainfall were recorded in consecutive years: 428 millimeters in 1976 and 130 in 177. Based on these trials, it is recommended that *A. senegal* be planted at a six by six meter spacing in the Sahelian zone, or at wider initial spacings--eight to 10 meters between trees--in agroforestry applications (Faye, B. 1983).

The first "bleeding" trials were conducted between December 1978 and March 1979 on *A. senegal* and *A. laeta* planted in 1974. For the first time in Senegal, the Sudanese method for tapping gum trees was used. This method employs an instrument that cuts less deeply into the tree, thereby incurring no damage to the sapwood and facilitating rapid healing of the wound. Theoretically, maximum gum production takes place between the ages of seven and 15 years. The trees tapped in these trials were only four to five years old and averaged 233 grams of gum exudations--collected every two weeks--for the season. The larger trees averaged 433 grams per tree with the biggest specimen yielding 2 kilograms of gum. This led to the hypothesis that gum production is directly related to tree size and that tree size is a genetic factor. If this holds true, then using superior parent trees for seed collection or vegetative propagation (cloning) may markedly improve gum production (IDRC 1979).

Variables other than tree size may influence gum yields and are also being examined. In 1979, experiments were launched to determine the effects of the time of year, the frequency of tapping, and the number of tapped stems per tree on gum production.

There have been experiments with bacteria of the genus *Rhizobium*, which enable certain leguminous plants to fix atmospheric nitrogen, and mycorrhizal fungi, which help plants to assimilate phosphorus. These are both found on the roots of gum trees. By identifying and isolating desired strains, seedlings can be inoculated to accelerate growth and reduce the required time in the nursery and also to increase the resistance of planted seedlings to eliminate stress (IDRC 1979). Work has been done on vegetative propagation--cuttings treated with hormones--to produce clones of high-yielding gum arabic.

Acacia seyal is being tested for its potential in producing gum. However, direct seeding of *A. seyal* has produced unspectacular results to date, obtaining only two percent germination. Trials were also started in 1982 to promote natural regeneration of *A. seyal* (Gueye 1982).

6.12 Forage tree species. Beginning in 1978, 250 hectares of forage tree species were established over a four-year period. The emphasis is on indigenous species, which although slow-growing are well known to the local population for a multiplicity of uses. Exotic species are also being tested for drought resistance and forage production. The long-term objective is to use these research findings to assist in the establishment of forage tree plantations around watering points.

Indigenous species trials include: *Acacia tortilis* and *A. nilotica* (three subspecies of each), *A. senegal*, *A. seyal*, *Balanites aegyptiaca*, and many species of the *Capparidacea* family that produces highly palatable and protein-rich forage (e.g., *Bauhinia rufescens* and *Combretum aculeatum*). Exotic species trials focus on the Australian acacias: *Acacia linarioides*, *A. pyrifolia*, and *A. tumida* (three provenances of each) as well as *A. holocericea* (*IDRC 1979*). These exotics retain their leaves during the long dry season and many trees, especially *A. holocericea*, were observed to perish three years after planting. Different treatments have been tried to improve survival: soil treatments--small and large hand-dug planting holes, tractor subsoiling and soil pulverization by disc harrowing; inoculation of *A. holocericea* with rhizobia and mycorrhizae; and weeding--mechanized and manual (agroforestry scheme with niébé bean intercropping).

A second aspect of the research on forage species involves nutrition and palatability. Woody fodder--pods, leaves, and stalks--constitutes a major portion of the diet of livestock, particularly in the long dry season when it represents at least one-quarter of the food intake

(Fleury 1981a). Therefore, the nutritive value of forage species are being determined during different seasons (especially the dry season) by four analyzes performed over two years to obtain the production rates of dry biomass and digestible protein. Palatability of forage species is difficult to evaluate because it varies with different animals, in different regions, and at different times of the year. Trials of both green and dry forage are being conducted with different species of livestock during different seasons. Pruning trials have also been carried out to determine the advantages of keeping trees at heights convenient for direct browsing by livestock (IDRC 1979).

6.2 Reforestation and Management of the Sylvo-Pastoral Zone

The project began in 1975 with financing from the Federal Republic of Germany (900 million FCFA) and counterpart funds (20 million FCFA). Offices and a vehicle workshop were established in Saint-Louis. The ultimate goal is to develop an integrated, sustainable agro-sylvo-pastoral system in the zone. The more immediate objectives are:

* restore ecological equilibrium around watering points;
* create forage reserves and wood supplies for the local population;
* improve gum arabic production; introduce *A. senegal* in agroforestry settings;
* aid in the limited development of subsistence agriculture (e.g., irrigated gardening);
* introduce range management techniques (e.g., rotational grazing).

Reforestation activities occur on state and community lands. The Rao Forest Reserve, much of which was degraded by overgrazing and overcutting, was protected by wire fencing. Understocked areas were planted with various acacias: *A. senegal*, *A. tortilis*, and *A. albida*. Degraded areas around certain watering points--including Windou-Thiengoly, Mbar-Toubab, Niassanté, and Takti--were reforested with gum arabic. Approximately 3,500 hectares were planted by the end of 1980 (André and Diouf 1980). This total had increased to over 5,000 hectares by the end of 1982. Earlier efforts concentrated on reforestation of state-managed lands, whereas more recently there has been greater local involvement in setting up community woodlots.

On state lands, plantations were established on a spacing of five by five meters after subsoiling by "Unimogs," all-terrain vehicles. For protection, either three-strand, barbed-wire fencing or large-mesh, "Australian" fencing was used. Villagers were paid for plantation work, including trials of digging shallow "water traps" around each planted tree. Some weedings were performed mechanically, although most weedings were done voluntarily by villagers, who fed the cut grass to their cattle. Judicious weeding is required in this zone to conserve soil moisture for the planted trees and to reduce the risk of fire. Some of the early plantations suffered high rates of mortality and were subsequently replanted.

In 1978, the project began working with the local population to establish community woodlots of gum arabic. "Bonus" payments were used as an incentive for villagers to take care of the woodlots; 100 FCFA were given for each seedling surviving after the first year and 50 FCFA per living tree for subsequent years. In the judgment of the project, this bonus will disappear by itself once villagers see the benefits of gum arabic (i.e., the first exploitation).

6.3 Lagbar Integrated Community Development

This project has been hailed as a "model of integrated community development" (Hoskins 1982). The Union Internationale pour la Protection de l'Enfance (UIPE) provided funds for the project, whose underlying philosophy is reflected in the credo: "To protect the child, one must protect the mother. To protect the mother, one must protect her environment" (Ndiaye, A. 1983b).

The Lagbar project is unusual in that the impetus was internal. Villagers recognized the increasing degradation caused by thousands of cattle attracted to their deep bore well, one of only six permanent watering points in the immense "réserve sylvo-pastorale des six forages" located in the Ferlo Valley. In an effort to remedy the situation, villagers sought outside assistance. International attention was generated by three European journalists, who documented the plight of Lagbar in a book (Pierre et al. 1981).

The project started in 1978 with several components that utilized personnel from various government services (e.g., the SWF as well as the Service de la Promotion Humaine). These activities included improved access to water, health and nutrition services, construction of a school, gardening, handicraft programs for women, and reforestation; all were priorities stated by the local population.

The goal of the reforestation component was to plant trees in an area extending one kilometer in radius around the village. Personnel from the SWF were assigned to Lagbar to create a nursery and coordinate reforestation activities. Eventually, 300 hectares of *Acacia senegal* and *A. tortilis* were planted, mostly in 25-hectare blocks with access passages left between blocks to permit livestock movements. The plantation received tractor subsoiling; trees were planted at five by five meters (400 trees per hectare). "Australian" fencing--large-mesh wire fencing that is very effective against livestock, especially goats--was erected around each plantation block at a unit cost of 400 FCFA per linear meter, inclusive of installation. Plantation establishment costs were estimated at 100,000 FCFA per hectare (Ndiaye, A. 1983b).

Only two full-time workers are paid, the rest of the labor is voluntary. As in all parts of the sylvo-pastoral zone, plantation weeding rarely poses any problems because herders, given the opportunity, will readily cut the grass for their livestock. In addition to the plantations, 14 hectares of "aires d'ombrage" were established by planting neems and *Prosopis juliflora* near the well to provide shade for the cattle after they have watered. This need was also articulated by the villagers.

The replicability of the Lagbar model of community development is reinforced by similar activities emerging in other localities of the sylvo-pastoral zone. In 1980, an analogous project began in Revane, located southeast of Lagbar. Similar actions are also envisioned at Namarel (CTFT/SCET 1982c).

6.4 SODESP

SODESP is a parapublic organization created in 1975 with the mandate of integrated range management. In 1979, USAID began a $8 million funding commitment to SODESP for a project that would modernize livestock production and address the deterioration of range resources around deep bore wells in the sylvo-pastoral zone. Efforts were focused on an area of a 15-kilometer radius around each of four well sites for a total of 280,000 hectares. An estimated 15 percent of project activities involved reforestation (Comings 1981).

The reforestation approach taken by SODESP is to work with herders to establish family plantations of gum arabic near their encampments. These are generally small woodlots, about one-half hectare, that can be maintained without much difficulty. Thus far, herders in the vicinity of Lagbar, Namarel and Tessekre have shown interest in this activity. A contractual agreement states the obligations of both SODESP--which provides tractor subsoiling, insecticides against termites, barbed-wire fencing, and seedlings grown by the SWF--and the herder, who provides labor for plantation establishment and maintenance (radius weedings of one meter around each planted tree) (CTFT/SCET 1982c).

Some intercropping is expected with niébé beans cultivated between the gum arabic trees. Niébés are an important crop in this zone because the beans provide nutrition for people while the vines are used as cattle feed.

7. SENEGAL RIVER BASIN

The Fleuve Region is named after the Senegal River--an important waterway that originates in the Fouta Djalon highlands of Guinea, flows through Mali, and forms the border between Senegal and Mauritania before emptying into the Atlantic Ocean near Saint-Louis. In the delta area around Saint-Louis, Wolof fishermen and farmers predominate. Toucouleur (closely related to the Peul) are the main ethnic group in the lower and middle Basin, between Dagana and Matam, where fishing and "double-cropping"--rainfed agriculture on higher lands and recessional farming on flood plains--are traditionally practiced. In the upper Basin, near Bakel, Soninké may be considered the major group although many ethnos are found.

Due to the lack of economic opportunities and the hardships caused by recent droughts, up to 30 percent of the active male population has emigrated from the Basin. It is believed that more than one-half of the original Toucouleur population now live in Dakar. Soninké men have developed a tradition of working in France and sending money home; as many as 80 percent of the men between the ages of 17 and 50 years are absent from some villages (USAID 1981).

The Government of Senegal is depending heavily on irrigated perimeters as a means of increasing agricultural production and generating economic opportunities for the Fleuve population. SAED is the parapublic agency responsible for the establishment and operation of large irrigated perimeters in the Basin. Land is appropriated from the traditional nobles, dyked up, and reallocated by a lottery system

(Metzel 1982). The type of agriculture introduced to farmers who gain cultivation rights is highly mechanized.

The future of the Senegal River Valley will be drastically changed with the implementation of the OMVS project (next section). For example, it is conceivable that 300,000 hectares of irrigated perimeters will be in place by the turn of the century. The development planned for the Basin will have wide-ranging implications for the existing forest resources.

7.1 OMVS

The Organization pour la Mise en Valeur du Fleuve Sénégal (OMVS) is a multinational project management agency set up by Mali, Mauritania and Senegal. Established in 1972, the OMVS was empowered to make decisions and management plans that are binding on its member states. Most of the financing is from multilateral and bilateral foreign assistance. It represents one of the largest and most ambitious river basin development projects--a huge $500 million hydro-agricultural complex (Fleury 1981b)--in West Africa.

The first phase of the project involves the construction of a salt water control dam at Diama, located within 100 kilometers of Saint-Louis, which began in December 1979 and is nearing completion. A second dam is planned for Manantali, Mali--1,100 kilometers upriver of Diama. This dam is expected to regulate river flow, thus permitting 255,000 hectares of land between Manantali and Saint-Louis to receive year-round irrigation, while producing 800 gigawatt-hours of electric power annually (USAID/MAB 1980).

The realization of this program will have overwhelming impact on the Fleuve populations and their traditional livelihoods; large-scale ecological disturbances appear inevitable. Critics of the OMVS contend that the organization is not adequately dealing with the potential loss in forest resources as a result of dam impoundment and agricultural conversion. Three major forest types are found in the Senegal River Basin: (1) gonakier (*Acacia nilotica*), (2) dieri (dryland Sahelian vegetation), and (3) upland savanna (found mostly in Mali).

The gonakier forest is the most important type in the Basin. It occurs in pure, dense stands on hydromorphic soils of periodically flooded areas. Approximately three-quarters of the 34,600 hectares of forests in the Fleuve Region are classified as gonakier; on the Mauritanian side of the river, more than 90 percent of the 25,500 hectares of forests are stands of *Acacia nilotica*. Growth rates are estimated to range from 2.3 to 3.9 cubic meters per hectare per year (Gannett et al. 1980).

Major losses of the gonakier resulted from the devastating drought of the late 1960s and early 1970s. Aerial photos taken between Rosso and Matam (middle Basin) in August 1977 revealed that 33 percent of forest reserves on the Senegalese side and 43 percent on the Mauritanian side of the river had died from drought. The greatest losses were in the gonakier type, some dieri forests also perished (Gannett et al. 1980). The SWF stepped up charcoal exploitation quotas in this area in an attempt to salvage the dead trees. Another source of gonakier mortality has been postulated. The diversion of river water for irrigation, combined with flood-control actions, may reduce the duration or amount of seasonal flooding in certain gonakier stands. This would adversely affect *A. nilotica*, a hydrophytic species.

The dam impoundments and the conversion of forests to irrigated, agricultural land will lead to the loss of an estimated 8,500 hectares of gonakier and 48,000 hectares of upland savanna and dieri (Gannett et al. 1980). Some compensating reforestation measures have been suggested, such as: the restoration of the gonakier in unaffected forest reserves by enrichment seeding, planting or protection of natural regeneration; the planting of windbreaks in irrigated perimeters; and the planting of gum arabic, forage and fuelwood species near villages and other settlements. Some of these much-needed activities are included in the following four projects.

7.2 Nianga Irrigated Plantation Trials

This experimental effort began in 1979 under the auspices of CNRF, with funding from the FAC (25 million FCFA in 1980). The project has received subsequent funding commitments to ensure its continuation through 1984 and possibly two more years beyond.

Irrigated plantations of *Eucalyptus camaldulensis* have been relatively successful in West Pakistan, Israel and North Africa (Pryor 1967). In Israel, annual growth ranging from 7.7 to 16.0 cubic meters per hectare were recorded for *E. camaldulensis*, irrigated between November and May to an equivalent rainfall level of 500 to 700 millimeters per year. There appeared to be a distinct period of dormancy from July to September when trees fail to respond to irrigation (Karschon and Heth 1967, FAO 1979).

For the Senegal River Basin, irrigated plantations are viewed as one alternative approach to cope with the projected increases in fuelwood demand and the reduction of existing gonakier forests expected from irrigated agricultural development. The Nianga pilot effort tests different methods of irrigating tree plantations, from sophisticated techniques to a simple one that would be within the scope of knowledge of farmers familiar with irrigated agriculture. The trials are established in an enclosed 25-hectare area of the Nianga irrigated perimeter, a marginal site for agriculture that was ceded to the project by SAED. This area receives very little rainfall, less than 150 millimeters per year during 1981-1982; the evapotranspiration demand is high--3,700 millimeters per year. The water table is situated only 1.3 to 3.0 meters below the ground surface (Sadjo 1983).

Four systems of irrigation have been installed:

1. "à la raie"--this simple system involves planting rows of trees in shallowly dug channels that are irrigated with hoses from the main irrigation canals (about four hours per week). Two doses are being tested that are equivalent to 700 and 1,100 millimeters of annual rainfall.
2. "Bas-Rhône"--this system utilizes hoses that run along the rows of trees. Cement supports are placed at intervals between two trees. At these supports, openings in the hose allow irrigation water to service adjacent trees. The flow, regulated by valves,

is more even than the one in the "à la raie" method. Doses of two, four, and six hours per week are applied.

3. Sprinkler--this system employs revolving sprinklers placed between rows of trees. Irrigation is applied at a rate of about two hours per week. Agroforestry trials are being conducted to fully utilize the water from sprinklers. Vegetables and/or grains are cultivated between rows of trees spaced six meters apart.
4. Submersion--this system is only possible on level terrain, where the entire plantation area is shallowly trenched. The area is filled once a week with irrigation water from a canal.

In addition to *E. camaldulensis*, many other species have been planted. Trials of exotic species and provenances included *Azadirachta indica*, *Eucalyptus alba*, *E. apodophylla*, *E. argilucea*, *E. brassiana*, *E. coileanii*, *E. crebia*, *E. exserta*, *E. jensenii*, *E. microtheca*, *E. pentaleuca*, *E. siccoteca*, *E. tereticorris*, *Gmelina arborea*, *Melaleuca leucadendron*, and *M. quinquinence*. Biomass trials utilized *Leuceana leucephala*, *E. grandis*, and *E. virophyla* planted at densities between 2,500 and 17,777 trees per hectare. Local species trials were established with *Acacia nilotica*, *A. adansonii*, *A. senegal*, *A. albida*, and *A. radiana*. In addition, a host of exotic and indigenous species were tested in forage species trials.

Using the Nelder spacing model, trials on initial plantation spacing were set up in plantations irrigated by the "Bas-Rhône" system. Also being tested are different methods of coppicing and shoot selection, potted versus "barbatelle" (stump) nursery stock, site preparation techniques, frequency and duration of irrigation, and fertilization.

Observations of certain growth trends in the 1980 and 1981 plantations of *E. camaldulensis* have led to the hypothesis that proximity to irrigation canals influences tree growth. A portion of the 1980 plantations was left as a non-irrigated control. Trees in the control plot, situated near an irrigation canal, were taller than those in neighboring plots that received irrigation but were further away from the canal. In a portion of the 1981 plantations, trees located on the outside edges of the block--and consequently adjacent to irrigation canals--had greater heights than trees in the center of the block. This observed phenomenon affirms the contention that *E. camaldulensis* is a vigorous exploiter of available groundwater.

Experimentation is underway to determine how the frequency and duration of irrigation influence the zone of root growth, between ground surface and the water table. There may be an optimal combination of frequency and duration that can shorten the period of irrigation required before tree roots "tap" into the groundwater.

7.3 Gonakier Restoration

The area of gonakier forest in the Senegal River Basin has drastically declined in the past ten years. The factors for this rapid decline are linked to the fact that the survival of *Acacia nilotica* is dependent on seasonal inundation. Moreover, the duration and lateral extent of annual flooding greatly influence the production rates in gonakier stands (Gannett et al. 1980).

In the wake of the severe drought circa 1968-1973, the overall mortality rate of gonakier in the Basin is variously estimated from 33 to 50 percent; in the Department of Podor, the 21 forests of the gonakier type suffered over 80 percent mortality (Guissé 1983). Natural regeneration is noticeably absent in the remaining stands due to overgrazing, trampling and consumption of seedpods by livestock. Irrigation activities have affected *A. nilotica* in two ways: (1) the conversion of some gonakier forests to agricultural land and (2) the diversion of river flow for irrigation, thus reducing seasonal flooding and lowering water tables--in effect, simulating drought conditions.

The negative implications of the OMVS development project have already been discussed in section 7.1. The OMVS study by Gannett et al. (1980) estimated that 8,500 hectares of gonakier forest would be lost due to the implementation of the project. The Master Plan for Forestry Development estimated that, potentially, 20,000 hectares of *A. nilotica* may be lost through agricultural conversion in the Basin (CTFT/SCET 1982c).

Due to the gravity of the present and future status of this important species, a project has been proposed to restore the gonakier in the lower and middle Basin--between Dagana and Saldé. The objective is to restore 5,000 hectares of gonakier: 2,500 by plantation and 2,500 by protecting natural regeneration. Funding was anticipated from Holland in time for the 1983 reforestation campaign, but administrative delay postponed the start-up of the project.

7.4 Podor Gum Arabic Plantations

In 1983, this project began in the Department of Podor. The goal is to establish 2,500 hectares of gum arabic plantations in five years. The project is financed by FED, the European Common Market development fund.

Historically, gum arabic has been one of the most important trade commodities of the Sahel. In the 18th century, the Compagnie du Sénégal, based in Saint-Louis, gained a monopoly over gum trade in the Basin. Production of gum arabic plummeted as a result of the last catastrophic drought; the Senegalese production fell from almost 10,000 tonnes in 1971 to 23 tonnes in 1975 (Table 15, République du Sénégal 1983b). In Senegal and Mauritania, *Acacia senegal* trees have suffered from an improper "bleeding" technique, introduced at the turn of the century, in which narrow pieces of bark are stripped and cuts made with an axe to stimulate gum exudations. Overtapping and tapping of immature trees have contributed to the degradation of gum arabic stands, as have livestock depredations and brush fires. The Sudanese technique, using an instrument that does not damage the sapwood, is being used at the Mbiddi Center (section 6.1).

A study in 1978 by the CNUCED (United Nations) and the GATT revealed optimistic prospects for the world gum market (IDRC 1979). Gum arabic is used in a variety of products including pharmaceuticals, foods, cosmetics, adhesives and inks. The expected increase in world demand is due to a preference for "purity" and "natural products," despite the emergence of many less expensive, synthetic substitutes for gum arabic (Giffard 1974b).

Table 15

Senegalese export of gum arabic during the period 1970-1981.

Year	Volume (tonnes)	Value (millions FCFA)
1970	9,418	1,391
1971	9,954	1,438
1972	2,907	451
1973	862	147
1974	1,411	782
1975	23	6
1976	205	28
1977	746	196
1978	572	141
1979	2,360	124
1980	492	128
1981	274	82

Source: République du Sénégal 1983b

Part of the fourth objective of the Master Plan is to increase the annual production of gum arabic to 10,000 tonnes in the year 2000 and to 20,000 tonnes in 2016. As of the end of 1983, some 10,000 hectares of gum arabic had been planted in Senegal. To reach the future production objectives--assuming an average annual production of 500 grams of gum per tree--50,000 hectares of plantations would have to be established before the year 2000 and 100,000 hectares by 2016. This translates to annual planting rates of 2,350 hectares of *A. senegal* between 1984 and 2000 and 3,000 hectares between 2000 and 2016 (Faye, A. 1983).

Two international conferences have been organized by the UNSO--the first in Dakar (June 1979) and the second in Saint-Louis (April

1983)--on gum arabic sylviculture and exploitation. Principal importers of Senegalese gum are France and other European countries.

The gum arabic project in Podor is designed to work through Rural Communities, which were installed in the Department in 1980. A central nursery was set up in Podor, with nurseries planned for three other localities in the Department. *A. senegal* seed was collected in the vicinity of Revane, in the sylvo-pastoral zone. Community plantations of gum arabic are to be established at a rate of 500 hectares per year over the five-year duration of the project (Guissé 1983).

7.5 Bakel Community Reforestation

This project was designed as a parallel effort to the project based in Louga (section 5.2). The long-term goal of these two initiatives is to introduce and sustain reforestation activities in order to mitigate desertification processes and to promote integrated systems of agro-sylvo-pastoralism. The zone of coverage of the two projects almost spans the entire width of Senegal--from Louga in the west to Linguère in the vast sylvo-pastoral zone to Bakel in the extreme east (upper Senegal River Basin).

The Bakel project is implemented by the FAO with funding from Swedish (380 million FCFA) and Senegalese (54 million FCFA) sources for a three-year period (FAO 1981d). The objective is to establish 2,000 hectares of rural plantations, which includes planting or restoring 1,400 hectares of gum arabic in the sylvo-pastoral areas near Bakel and planting 600 hectares of fruit orchards in areas adjacent to the Senegal River.

Because the Rural Community structure has been implanted in the Senegal Oriental Region but recently, the project works at the village level as well as with the newly formed Rural Communities. The local population provides land and labor for plantation establishment while the project furnishes technical assistance, seedlings and mechanized subsoiling in areas of lateritic soils. There is collaboration with the SAED and with the USAID irrigated perimeter project in Bakel.

The project started in 1983 with the installation of a 40,000-seedling nursery. *Acacia senegal* seed came from the Mbiddi Center, which contributed eight kilograms of seed, as well as Mauritanian sources. Over 60 people worked in the nursery; "food for work" from the WFP was distributed. About 20 villages were integrated into the project, which had a reforestation target of 515 hectares for its first year (République du Sénégal 1983a). Large plantations were to be protected by means of "Australian" or barbed-wire fencing; natural fencing (live and thorn-branch enclosures) was envisioned for smaller woodlots (Niang 1983).

Part C

ANALYSIS

8. CONSTRAINTS

8.1 Ecological

8.11 Climate. In Senegal, the harsh and unpredictable climate is a source of great stress on reforestation efforts. Rainfall has not returned to pre-drought levels. Over the period 1967 to 1979, annual rainfall declined 25 to 70 percent, depending on the region, in comparison to "normal" averages recorded for the 1931-60 period (République du Sénégal 1983a).

The distribution pattern--both temporal and spatial--of rainfall is as equally important as the total amount. In Senegal, as in most of the Sahel, the distribution of rainfall is highly localized and erratic. The tendency for "mosaic rain," as described by El Hadji Sene, Director of the SWF, means that villages a few kilometers apart may receive (or not receive) highly variable amounts of rainfall (Fleury 1981a).

Concerning the temporal aspect of rainfall distribution, one recent pattern in the Groundnut Basin appears to be a few rains in late June or early July followed by a few weeks of rainlessness before rainfall resumes in the latter part of July. This pattern was greatly distorted in 1983, when two or three significant rains fell between June 20th and July 10th in the Thies and Diourbel Regions but was followed by a dry spell that lasted five to six weeks. This wreaked havoc on tree planting operations. The Bandia plantation site, for example, received only 238 millimeters in 1983 as opposed to an average of 373 for the previous three years.

This erratic pattern causes a dilemma. Some planting crews were operationalized after the second significant rain, when the 50 to 100 millimeters of accumulated rainfall were thought to have adequately moistened the root zone portion of the soil horizon. Unfortunately, the long dry spell afterwards led to high mortality of seedlings planted in the first half of July. Other operations that opted to wait for additional rain were left waiting until late August. This created problems vis-a-vis oversized nursery stock (e.g., root spiraling) and greatly diminished post-planting rainfall due to late planting. Overall, both the quantity and quality of tree planting suffered tremendously in 1983.

Another stressful climatic factor is the high evapotranspiration rates found through Senegal, with the exception of the coastal areas where the "alizé" winds are predominately humid. This is especially a problem for fast-growing exotics such as *Eucalyptus camaldulensis*, a species that, in its native range of Australia, is known to be uneconomical in its water usage and will maintain high transpiration rates, with stomatal closure occurring only at stages of permanent wilt (Pryor 1976).

8.12 Edaphic factors. Many of the sites that are available for reforestation can be classified as marginal or even submarginal due to one or more of the following edaphic conditions: lateritic hardpans, low fertility, high salt content or periodic flooding. This is especially true for village or Rural Community efforts in populated areas, where seldom is arable land ceded for woodlot establishment. Analysis of the three main soil types encountered in this study--"dior," "deck" and "tanns"--are presented in Table 16.

The saline and hydromorphic "tanns" soils pose difficult problems for reforestation efforts. Hopefully, the ongoing research with *Melaleuca* spp. and other trees that can tolerate these edaphic conditions will provide some potential solutions.

In general, "dior" and "deck" soils have suitable textures for tree cultivation, barring lateritic hardpans that occur within a meter or two of the surface. Problems of nutrient deficiency usually appear only when the clay content is below two percent, as in the case of sand dunes (Jensen 1974).

Another important factor is moisture retention. It is often assumed that "deck" soils have greater moisture retention than "dior" soils due to drainage characteristics associated with soil texture. However, during dry spells--such as the rainless period apt to follow the first few rains (see Section 8.11)--evaporation potential affects water availability to planted trees. On "dior" soils, only water that is retained in the upper 50 centimeters of the soil horizon is susceptible to evaporation; the vast majority of rainfall infiltrates below this depth and, hence, is available to the root systems of trees. On "deck" soils, evaporation of soil moisture can occur to a depth of 90 centimeters (presumably because of greater capillary tension). Since most of the moisture is stored in the upper 50 centimeters of "deck" soils, evaporation during dry periods can rapidly deplete the water available to trees (PRECOBA 1982c).

Table 16

Analyses of "dior," "deck" and "tanns" soils.

Soil Type	Horizon (cm)	Organic Matter	Clay	Silt	Fine Sand	Coarse Sand	Chloride	pH
		-----------	----------	-percent-	----------	----------	----------	
(a) Dior	0-25	0.2	3.0	1.4	62	33	--	4.5
	25-60	0.1	2.8	1.4	64	31	--	4.5
	>60	0.1	2.6	1.0	62	34	--	4.5
(a) Deck	0-25	1.2	10.8	4.0	68	16	--	5.4
	25-60	0.4	18.2	4.8	62	14	--	5.6
	>60	0.3	18.7	3.8	64	13	--	5.0
(c) Tann	0-20	--	8.1	0.4	83	8	0.7	
	30-40	--	10.2	3.5	82	3	0.7	?
	70-80	--	3.9	1.1	90	5	0.7	

Sources: (a) Beye 1966a
(b) Beye 1966b
(c) Bonfils and Faure 1955

Lateritic hardpan, often situated one meter or less below ground level, can induce mortality or stunt the growth of planted trees, as witnessed in the Bandia eucalypt plantations of 1980 (section 4.1). The symptoms of this problem may not show up until two or three years after planting, when the root systems fail to penetrate the hardpan horizon. For large-scale plantation efforts such as PARFOB and PARCE, detailed soil surveys that can indicate areas of lateritic hardpan are indispensable.

8.2 Technical

Although there is a general tendency to believe that technical solutions exist and that the major constraints to reforestation are of a socio-economic nature, this is not entirely the case in Senegal, nor in the rest of the Sahel. Problems with the introduction of fast-growing exotic species and the cost-effectiveness of reforestation projects are indications that the available technical packages are problematic.

8.21 Fast-growing exotics. One major unresolved technical problem is the lack of appropriate fast-growing, exotic species that can withstand the environmental stresses discussed above and maintain production rates that are economically feasible--in light of the high financial (i.e., mechanization) and economic (e.g., opportunity cost of natural forest conversion) costs associated with large-scale plantations.

It is becoming increasingly evident that *Eucalyptus camaldulensis*, touted as the most recent "miracle tree" in the Sahel, is an inappropriate selection for most of the Sahelian and Sudanian zones of Senegal (except in areas where groundwater of good quality and accessibility is present). The riparian nature of this eucalypt in its native range cannot be neglected in species-site selection. In the moister Guinean zone (e.g., the Casamance Region), species such as *E. tereticornis* would be selected over *E. camaldulensis* due to superior growth and form.

8.22 Cost-effectiveness. This is another major constraint of existing technical packages. In large-scale reforestation, the costs of mechanization are high and proper maintenance of heavy equipment is often lacking; direct costs of plantation establishment often range from $800 to $1000 per hectare. That, coupled with the disappointing yields of exotics such as *E. camaldulensis*, has led to an untenable economic situation. This was reflected in the Phase I evaluation of PARFOB (section 4.1), which determined that the project was economically infeasible (Freeman 1983).

In social forestry initiatives, certain high-cost components are incompatible with the small scale of the operation and unsustainable from the standpoint of the financial resources at the disposal of the Rural Community, the village, and the farmer or herder. For example, the "Australian," wire-meshed fencing used in the 1982 woodlots of the Diourbel project (section 5.4) was prohibitively expensive, as illustrated in Table 17. It has been calculated that the "Australian" fencing system is cost-effective only if the woodlot surface area exceeds 30 hectaress (Ulinski 1983). This is well beyond the scale of virtually all social forestry initiatives in Senegal; the average size of the 1980 Diourbel woodlots was less than one hectare.

Table 17

Costs of "Australian" fencing used in the Diourbel village reforestation project.

Woodlot Area (ha)	Woodlot* Perimeter (m)	Cost per Woodlot**	Equivalent Per Hectare Cost
		------------FCFA---------------	
.25	200	80,000	320,000
.50	283	113,200	227,400
.75	347	138,800	185,067
1.00	400	160,000	160,000

Source: Lai 1983

* assumes a square area; most woodlots are actually rectangular or trapezoidal, thus increasing the actual perimeters and fencing costs.
** based on a unit cost of 400 FCFA per linear meter (installation included).

The preceding discussion naturally raises the question of sustainability. It appears that many technical components that have been introduced are ecologically and economically unsustainable. Even if technological fixes can be developed to loosen these bottlenecks, the ultimate criterion is "social sustainability": Will the technical package be culturally acceptable and can it operate within the constraints of the socio-economic context?

8.3 Social

8.31 Land availability. In densely populated rural areas, such as the Groundnut Basin, land scarcity is a major constraint to reforestation efforts. Given the present land-use situation, summarized in Table 18, it is not surprising that lands "donated" or designated for woodlot establishment are usually on "marginal" sites. This accentuates the problems associated with the severe edaphic factors discussed in section 8.12.

Table 18

Land-use patterns in Diourbel and Thies Regions.

Region	Department	Arable	Cultivated	Fallowed	Marginal	Total
		percent				
Diourbel	Bambey	82	82	0	18	100
	Diourbel	96	96	0	4	100
Thies	Mbacké	70	65	5	30	100
	Thies	69	59	10	31	100
	Tivaouane	85	69	16	15	100
Weighted Mean		80	72	8	20	100

Source: NAS 1980

In the Diourbel village reforestation project, the trend for land donated for woodlots is toward small depressions ("bas-fonds") located close to the village, marginal sites that are not cultivated. The soil is usually of the "deck dur" type--very compact, seasonally inundated, and subject to severe drying and cracking during the dry season. This represents a very difficult environment for planted seedlings; the only solace is that the availability of soil moisture in the "bas-fonds" extends into the dry season. *Eucalyptus microtheca* merits further attention on these sites based on its ability to tolerate extreme conditions in experimental plantings.

8.32 Labor availability. The short critical period for tree planting coincides with a period of peak agricultural activity. Likewise, the desired early weeding of woodlots, to mitigate the depletion of soil moisture by herbaceous plants, overlaps with weeding work in the fields. There are no clear-cut measures to sidestep this competition for labor, especially in cases where reforestation work is non-remunerative. Arrangements must be devised according to possibilities that exist at each locality. For example, in some villages engaged in the Diourbel project, the "reforestation committee" agreed to plant trees during their "day off" from the fields.

In scrutinizing the agricultural calendar, the period from January to March is the one in which men have the most leisure time. It logically follows that this period should be used to perform as many reforestation-related tasks as possible: nursery set-ups, site preparation and site protection.

8.33 Equity. Equity in distribution of benefits may well be the bottom line to project sustainability or failure. Fred Weber, one of the patriarchs of international assistance in Sahelian forestry, believes that communal forestry projects have not worked in the region because benefits failed to reach the local population as planned (Weber 1982).

In Senegal, although most reforestation projects have not yet reached the initial harvest, it appears that the perception of benefit distribution varies with the level of intervention--individual, village or Rural Community. It also seems that as the unit scale of the operation increases, so does ambiguity over the distribution of benefits.

With individual endeavors, such as the approach taken by SODEVA and SODESP, the costs and benefits of establishing a small woodlot are clear to the farmer or herder. Equity, therefore, is a non-issue in this setting.

At the village level, the perception of distribution of benefits is largely dependent on the group dynamics of the "groupement de reboisement" or the "comité de reboisement" that are organized to carry out the reforestation work. When there is solidarity amongst the members--be it familial bonds, ethnic homogeneity or common religious affiliation (Moslem brotherhoods exert strong influences on social dynamics and mechanisms in Senegal)--collective action can occur effectively.

In the Diourbel project, the members of the reforestation group, commonly a core of 10 to 20 villagers, contribute their labor in the nursery and woodlot and are expected to share in the future benefits. However, as Noronha (1980) pointed out: "There is no tradition of growing trees that falls within the rubric of traditional communal action." Therefore, collective action should be viewed as a variable, not as a given. In villages where traditional authority has badly eroded--those fraught with factionalism and competing sub-groups--the capacity for activities such as village woodlots may be greatly reduced or completely lacking.

Projects such as PRECOBA and the FAO reforestation efforts based in Louga and Bakel intervene at the level of the Rural Community, which allocates land and mobilizes labor for the establishment of community woodlots. In time, this entity is expected to be self-sufficient in the management of woodlots, with proceeds from woodlot harvests going to the Rural Community treasury and, ostensibly, a portion of these revenues being reinvested to sustain reforestation activities. Whether this will occur as planned remains to be seen. Already, some questions are being raised with regard to the ability of Rural Communities to mobilize the required financial and human resources and with regard to whether woodlot revenues will be reinvested or expended on other priorities such as mosques, wells, schools and health dispensaries.

The equity issue is perhaps the most complicated at the Rural Community level. The emerging trend is that members of villages that are situated near the selected woodlot site usually provide more labor than outlying villages. How should equity in benefit distribution be interpreted in this case? How do villages that provide more labor perceive their future share of the benefits? How will the Rural Community allocate benefits among its constituency of villages and villagers?

8.34 Land and tree tenure. Both customary and formal laws reinforce tree ownership rights, although customary regulation ascribes use rights to the person who has tended the tree (planting and/or protection) while forestry legislation tends to associate tree tenureship with the individual who holds the land cultivation rights. The forestry code is ambiguous concerning use rights to naturally regenerated trees that are raised in fields. Of course, "protected" species such as *Acacia albida* require a special permit from the SWF if the farmer wishes to "exploit" the tree.

The different sets of customary and legal frameworks for interpretation of land and tree tenure could create conflicts and complicate reforestation efforts. As discussed in section 5.1 on PRECOBA, 97 percent of all land in Senegal is considered national domain, owned by the state. The President of the Rural Community Council is empowered to allocate and arbitrate land-use rights along customary lines.

Returning to the Diourbel example, land for establishing a village woodlot is usually donated by a "rich" individual with large holdings. Two stipulations may be retained by the donor: that when the woodlot is weeded, the herbaceous material is given to his livestock; and that if the woodlot operation is discontinued, the land rights revert to him. The actual work is conducted by a "reforestation group," who will ultimately share in the benefits from the woodlot. In addition, where the village woodlot, or a portion thereof, is located on arable soils, some agroforestry application can be expected--be it the intercropping of peanuts or garden vegetables such as eggplant and squash (Lai 1983). In this scenario, different land ownership, tree ownership and cultivation rights may exist on the same hectare of woodlot. In situations such as this, ownership and use rights must be clearly spelled out and understood in order to avoid conflicts between different user groups or individuals.

8.4 Institutional

Institutional constraints revolve around what Taylor and Soumaré (1983) referred to as "absorptive capacity and recurrent costs: the twin issues of pace and sustainability." Indeed, a careful analysis of the present and projected levels of funding and staffing is crucial to realistic planning and implementation in the forestry sector.

8.41 Funding. Domestic financing of the forestry sector is very low. Within the framework of the Senegalese four-year national development plans, investments budgeted for forestry decreased from 11,891 million FCFA for the Fifth Plan (2.9 percent of total investment) to 10,663 million FCFA for the current Sixth Plan (2.3 percent of the total). The Master Plan for Forestry Development asserted that this reduction occurred not necessarily because forestry was given a lower priority in the Sixth Plan, but because of the limited ability of the sector to absorb future investments (CTFT/SCET 1982a).

In Table 19, the projected funding levels for the period 1981 to 1997 are compared to the forestry investments required to meet the objectives stated in the Master Plan (section 2.2).

With projected funding expected to remain relatively low, the realization of the long-term strategy in the forestry sector will be

Table 19

Comparison of projected and required funding in the forestry sector, 1981-1997

National Development Plan	Period Covered (July 1-June 30)	Total Investment (millions FCFA)	Projected Forestry Funding (millions FCFA)	(as % of total investment)	Required Funding to meet Master Plan Objectives (millions FCFA)
Sixth	1981-85	463,847	10,665	2.3	10,258
Seventh	1985-89	512,100	13,310	2.6	18,374
Eighth	1989-93	565,300	16,960	3.0	37,151
Ninth	1993-97	624,100	21,849	3.5	62,981

Source: CTFT/SCET 1982a

contingent on external funding. This is a problematic achievement given that international assistance is often short-sighted and more consistent with political objectives than real needs.

One funding mechanism that must be closely monitored is the so-called Title III program, which permits Senegalese funds used for the purchase of American grains to be diverted to earmarked development projects. As mentioned in section 3.3, only about 40 percent of the projected funding has reached the PL-480 Dune Stabilization project, mainly due to the poor marketability of the higher-priced American rice. Yet, USAID has recently chosen Title III as the principal financing source for their portfolio of reforestation and energy programs in Senegal. Hopefully, this will become a more effective funding mechanism due to the following reasons: better commodity mix (sorghum and rice); a more competitive pricing structure; and greater influence in the allocation of commodity fund transfers by the Management Committee because of a "block" of recipient forestry projects as opposed to only one in 1981-82 (Rifkan 1983).

8.42 Staffing. The insufficient number of qualified forestry personnel is, and will continue to be, a real constraint to forestry development. Senegalese forestry staff fall into three categories:

* professional--Ingénieurs des Eaux et Forêts (IEF), Grade "A".

* subprofessional--Ingénieurs des Techniques des Eaux et Forêts (ITEF), Grade "B".

* technical--Agents Techniques des Eaux et Forêts (ATEF), Grade "C".

Technical training is given to the ATEF at l'Ecole Nationale des Agents Techniques des Eaux et Forêts (ENATEF) in Djibelor (near Ziguinchor); the school receives Swiss foreign assistance. The ITEF are trained at l'Ecole Nationale des Cadres Ruraux (ENCR) in Bambey. To date, virtually all the IEF have received advanced education at institutions overseas (e.g., France, Canada, U.S.); IEF programs are being set up at l'Institut d'Environnement (Dakar) and l'Institut Nationale de Développement Rural (Thies).

Although current annual targets are 15 subprofessionals and 30 technicians, the graduating classes from ENCR and ENATEF are frequently below these levels. To meet the projected staffing needs, ENCR and ENATEF would have to boost the annual number of graduates to 25 and 80, respectively, in 1985 and to 40 and 120, respectively, by 1997. This would require significant investment in the expansion of the physical and teaching infrastructure.

Table 20 presents the current staffing situation and the projected personnel needed to meet reforestation objectives.

Staffing constraints go beyond the quantity of trained personnel. Criticism of the current programs of forestry training includes the chronic shortage of teachers and the lack of practical instruction at ENCR. Training at both schools is focused on technical forestry aspects (CTFT/SCET 1982b). This, in combination with the common image of the

Table 20

Present status and projected needs of forestry staff.

Personnel Category	Staff in Service	Staff in Training	Total Available by 1985	Projected Staffing Needs 1980-1985	Projected Staffing Needs 1985-1990
IEF	11	30	41	40	50
ITEF	93	33	126	131	226
ATEF	293	39	332	880	1550
Total	397	102	499	1051	1826

Source: CTFT/SCET 1982b

forester as police (a colonial legacy that is still the hallmark of Sahelian forestry), results in poor extension abilities. In order for rural reforestation work to progress, the SWF personnel must become better extension agents. Revision of curricula may bring desirable results. In the meantime, short refresher courses offered at the training center established by PARCE (section 4.2) will aid in providing in-service foresters with training in extension and other vital areas.

9. IMPLICATIONS

This study--which combined field work at a micro-level with analysis of planning, research, and implementation at the national level--had the immense advantage of perspective in hindsight. This facilitated the extraction of "lessons learned" from reforestation efforts. It must be strongly emphasized that the critical tone of this paper was put forth not to condemn individuals, organizations, projects or approaches, but to serve as a pedagogical tool: so that we can all, collectively and individually, learn from our mistakes instead of repeating them.

As Jeff Romm, one of the more creative thinkers in forestry, espoused: action is the key. We can only learn if something has happened; but "actions without learning" are rather pointless.

The many projects and approaches to reforestation in Senegal offer valuable insights that can benefit not only future efforts in Senegal but in the Sahel and other regions as well.

9.1 Planning Level

The mere fact that Senegal has developed a comprehensive, long-term Master Plan for Forestry Development--the only Sahelian country that has undertaken this important task--is an extremely positive indicator. However, the long-term objectives of the Plan appear to be overoptimistic given the limited financial, human and land resources available to the forestry sector.

The Master Plan projected that the majority of reforestation will have to be in the form of rural plantations. This projection is predicated on the realization that forest reserves and other state-controlled lands have insufficient sites suitable for plantation establishment. However, the availability of suitable sites in the rural sector is dubious, at least in populated areas such as the Groundnut Basin (see Section 8.31 and Table 18).

Although the Plan recognizes the importance of natural forest management and conservation measures (see section 10.6), it is heavily biased toward plantation establishment. Moreover, there is a bias, current and projected, in favor of externally-funded, short-term projects as the vehicle for attaining reforestation goals. Problems are inherent in both biases.

9.2 Project Level

9.21 Project design. In a profession that is self-proclaimed as long-term (even with fast-growing exotics), virtually all foreign-assisted forestry projects in Senegal are short-term (less than five years of projected funding) with goals that are often unrealistic in light of the short time horizon involved.

Many efforts suffer from a project design phase that serves more to mollify internal bureaucratic procedures than to realistically assess the environmental, social, technical and institutional constraints within which the project must operate. There are numerous examples where shortcomings in the design phase ultimately led projects astray.

The erroneous nature of the major technical assumptions used in designing PARFOB (section 4.1) illustrates this point. Other projects have incorrectly assumed that communal land and collective action are intrinsic to rural societies and can be tapped for reforestation purposes. The initial concept of nine-hectare village woodlots in the Diourbel project (section 5.4) violated the land constraint of the most densely populated rural area in Senegal.

One commendable aspect of PRECOBA (section 5.1) is that the first year of project "implementation" was more or less an extension of the design phase, with technical and sociological studies aimed at learning more about the local population and resource situation. In this way, site-specific information can be used to validate, modify or refute prior assumptions about the human and natural environment.

This type of gradual transition from design to implementation appears desirable for more than one reason. Not only does it allow additional time for local environmental assessment, but a built-in transition period may help alleviate many problems associated with lengthy logistical procedures: e.g., material procurements, tariff exemptions, mobilization of funds and personnel.

9.22 Project implementation. The various approaches and techniques used in reforestation in Senegal will provide a good comparative basis for generalizing on what seems to work best in certain situations. Of particular interest are:

1. the intervention level--individual or family, village, and Rural Community;

2. the delivery mechanism--autonomous projects, the SWF Regional Inspectorates, and collaboration with rural development agencies (e.g., SODEVA, SODESP, SAED, STN);

3. the incentive system--remunerative labor, "food for work," potential private sector initiative.

Obviously, the "proof of the pudding" will be the sustainability of these reforestation efforts, employing different combinations of approaches, beyond the funding period or initial harvest. However, based on observations and evaluations in the field, some preliminary generalizations can be made:

* Reforestation efforts carried out by individual farmers or herders appear to work well, the degree of success largely dependent on the quality of extension services. At present, rural development agencies are best equipped to intervene at this level because of their comparative advantage in extension work.

* There appears to be a negative correlation between reforestation success (i.e., tree survival rates) and the scale of the operation (i.e., woodlot size). However, the impact of these small-scale efforts on regional fuelwood deficits will remain minimal or negligible unless there is systematic diffusion and adoption of such activities. Seen from a purely production point of view, scattered individual or village woodlots, ranging from one-quarter to one hectare, will not significantly affect the fuelwood problem in the overpopulated Groundnut Basin.

* Interventions at the Rural Community level (e.g., PRECOBA) represent medium-scale operations--woodlots of 10 to 20 hectares--that have the potential for surplus production. This surplus may help alleviate the fuelwood imbalance in urban and congested areas as well as generate revenues to sustain reforestation efforts.

* The future role of large-scale reforestation, at least in the plantation sense, is unclear based on the accumulated experience. Efforts to establish highly productive fuelwood sources near urban and other areas of great demand were predicated on the sound rationales of reducing transportation costs and easing the degradation of natural forests exploited to supply cities with fuelwood. However, the tough ecological constraints (section 8.1) made these "peri-urban" efforts

technically and economically infeasible. One possible alternative would be to move these efforts further south to more favorable rainfall zones (e.g., the Casamance Region). This, however, is an improbable proposition because (1) those areas still have extensive forest cover and (2) the problem of transport distance would reappear.

9.3 Research Level

Forestry research in Senegal is handicapped by a number of problems. One is the segregation of forestry research and implementation under two ministries. The National Center of Forestry Research (CNRF), a branch of the Senegalese Institute of Agricultural Research (ISRA), is under the auspices of the Secretary of State for Scientific and Technical Research (SERST). On the other hand, the SWF operates within the recently created (1983) Ministry for the Protection of Nature.

Along with this physical segregation is an ideological one. Senegalese criticism of CNRF, which comprises mainly French and Belgian researchers, have ranged from "they do not conduct research, they plant trees" to "they conduct esoteric research in a vacuum." Much of this criticism seems warranted. However, CNRF does function under severe fiscal constraints (see section 2.3), which limits their range of research activities.

In areas where potentially valuable findings have resulted from research, dissemination channels are sorely lacking. For example, the discovery of *Eucalyptus microtheca* as an apparently suitable species for "deck dur" soils (highly compact clays prone to seasonal inundations), based on experimental plantings at the CNRF station in Bambey, has not been applied elsewhere.

It is clear that better linkages must be developed between CNRF and SWF; one proposal is to bring both organizations under a common ministry. The recent trend of conducting "complementary" research tied to operational projects (see section 2.31b) is laudable and practical, a way for CNRF to do applied research that is funded by projects.

The dissemination caveat is, ultimately, the one that must be addressed in order for research to be useful to forestry practitioners. Not only do effective mechanisms of disseminating research findings have to be developed, but Senegalese and other foresters must be convinced that these findings are credible, practical and applicable in the field.

Furthermore, on-site experimentation should be encouraged. In the Diourbel project, activities such as the trial propagation and planting of many indigenous tree species as well as experiments to evaluate the effects of "grands potets" (large hand-dug planting holes) versus those of tractor subsoiling serve as a model of applied research that is simple, inexpensive, site-specific and integrated into operational projects.

10. DISCUSSION AND RECOMMENDATIONS

10.1 Collaboration

10.11 Donor-implementor interface. The need for greater collaboration between and within all entities involved in reforestation in Senegal is self-evident; the means for fostering this collaboration are not as clear. The following are suggested as possible ways, both formal and informal, of "networking" forestry donors, researchers and practitioners:

* greater joint input to the planning and programming of reforestation strategies and projects within a long-term time horizon;

* exchange of site visits by forestry personnel to discuss problems and ideas of mutual interest;

* more seminars and workshops organized around specific reforestation topics and techniques;

* systematic compilation, analysis and dissemination of useful research findings;

* development of appropriate vehicles for information sharing (e.g., newsletters): status and progress of projects; timely news concerning personnel, meetings, research and special problems.

10.12 Agriculture-forestry interface. In addition to greater cooperation at the level of donor and implementing agencies, there is a pressing need for more joint ventures between the traditionally distinct sectors of forestry and agriculture. The recent entry of parapublic rural development agencies (e.g., SODEVA, SODESP, SAED) into the forestry domain has prompted perceptions of a "turf battle" among some forestry traditionalists. However, the different comparative advantages inherent in the rural extension services as opposed to the SWF argue for a complementary working relationship. While the strength of the rural development agencies is in providing extension services to farmers and herders, their agents often lack expertise in technical skills. The converse is true of the SWF agents.

Therefore, a collaborative working arrangement between these two sectors could result in valuable "on-the-job" training and exchange for personnel of both disciplines as well as promote an integrated approach to reforestation. This would loosen the institutional constraints to implementing agroforestry schemes--intercropping and windbreaks that are greatly needed in the Groundnut Basin and other areas--which have long suffered from the obstinate and separatist views of foresters and agronomists alike.

10.2 Sustainability

The dependence of Senegal on external funding for a vast proportion of current and projected reforestation activities inevitably raises the question of sustainability of these efforts beyond the usually short funding period. Of particular concern are capital-intensive, highly mechanized projects that require substantial infusions of foreign currency and technology. The financial and technical ability of the Senegalese to support such projects, in the absence of foreign assistance, is dubious at best.

The deficiencies of the project-oriented bias that is common in Sahelian forestry, Senegal notwithstanding, has been deftly pinpointed by George Taylor, who argued that "process and context" are the "keys to improved project performance" and that sustainability is intimately related to "absorptive capacity and recurrent costs" (Taylor and Soumaré 1983).

In this light, the key to the continuity of efforts initiated by projects is to develop processes that are sustainable within the given environmental context. Attempts should be made to substitute external funding and technologies with indigenous ones whenever and wherever possible. This may be more feasible in medium- and small-scale rural projects, where some shifts to locally sustainable strategies have already begun.

For example, in the PRECOBA effort, each Rural Community is expected to budget 300,000 FCFA per year to defray woodlot establishment costs and is expected to be financially autonomous once revenues are generated from woodlot harvests. PRECOBA emphasizes locally available resources (e.g., horse-carts to transport seedlings, manual site preparation) over mechanized or introduced one. In the third-year evaluation of the Diourbel project (Lai 1983), recommendations were made to replace expensive, non-indigenous technologies--wire fencing, tractor subsoiling--with simple, less expensive techniques that can be equally effective--live and thorn-branch fencing, large hand-dug planting holes.

10.3 Replicability

The issue of replicability is crucial given that most current efforts in reforestation fall under the rubric of "pilot" or "experimental" projects. In this vein, the most important function of these projects may well be to serve as a demonstration to the local population that certain activities are feasible and beneficial to them.

In scanning across the gamut of reforestation efforts throughout Senegal--both introduced projects and indigenous initiatives such as *Acacia albida* and ronier palm silviculture--there are many localized successes. The problem then becomes one of diffusion. How can these successful models be systematically diffused beyond their immediate origins?

There is an intrinsic, osmotic phenomenon to the spread of innovations: from one farmer or herder to another, from one village to the next, and between Rural Communities. However, this type of random diffusion generally occurs in a haphazard--and often inconsequential--pattern. In social forestry projects, especially those located in land-scarce regions, the most successful have usually been the smallest in scale, often one-half hectare or less. While these will undoubtedly have favorable impact at the family level, and possibly at the village level, the present pattern of small, dispersed woodlots will not contribute significantly toward solving the problem of regional fuelwood deficits.

It would appear that effective methods of extension may aid in more rapid and systematic diffusion of reforestation in rural areas. The demonstration value of successful efforts--be it a village nursery, a woodlot, or protection of *Acacia albida*--should not be underestimated. One example of this value is taken from the Diourbel project. Peace Corps Volunteers based in villages arranged a "tournée" to take selected villagers to each other's nurseries and to visit sites where project woodlots had been established the previous year. This one-day trip generated a tremendous amount of enthusiasm and motivation among the participating villagers, who learned a great deal from the experience of their peers.

10.4 Institutional Reform and Strengthening

10.41 Training. Funding and staffing constraints, including project shortages of qualified forestry personnel, were discussed in section 8.4. Substantial investment is needed to expand and upgrade the forestry training facilities. But along with merely increasing the number of trained individuals is the need to reorient the type of forestry education they receive and the institutional role they play. Greater emphasis must be put on applied field work and appropriate extension training.

The advantages of a "participatory" leadership style of forestry agents--where local participation is solicited and integrated into reforestation efforts--over the more traditional "authoritarian" role are increasingly evident. In many cases, participatory management (or the lack thereof) is considered to be the single most important factor in determining the success or failure of forestry projects (Wunsch 1980). Only through a concerted effort to adopt this approach in dealing with villagers can forestry agents shed their persistent police image.

10.42 Legislation. The national forestry code is a colonial legacy designed to, but ineffective in, promoting conservation by freezing demand through the creation of extensive forest reserves and "protected" species legislation (Thomson 1981). There are well-documented instances where the consequences of this strategy are completely opposite to its intent.

For example, many Serers--the masters of *Acacia albida* silviculture in Senegal--discontinued their traditional culture of the kad tree as a response to being fined by forestry agents for exploiting, without a permit, a "protected" species that Serers had nurtured in their fields (Pelissier 1966). The nebulous status of the forestry code with regard to trees in fields must be clarified and in favor of whomever tended the trees.

One possible incentive to encourage rural reforestation activities--and help address the replicability issue raised in the previous section--would be to legally define tree ownership rights. By formally guaranteeing the future benefits of reforestation to the individual or group responsible for undertaking the task, the rural populace would have greater incentive to pursue better measures for the protection and maintenance of trees. The revision of the forestry code could yield many desirable results with regard to the quantity and quality of rural participation in reforestation.

10.5 Private Sector Initiative

10.51 Privatization. The concept of defining tree ownership rights is aligned with "privatization" as put forth by Jamie Thomson (1983). The ultimate aim of privatizing tree ownership is to act as a positive incentive to protect trees--planted or natural--whether the action is done collectively or individually.

This critical issue seems to transcend regional boundaries. The primacy of tree ownership is reflected in the Chinese context (as far removed from the Sahel as one can get), where forest destruction has apparently increased each time the promise of tree ownership was violated; ownership rights were finally given statutory guarantee by the Forestry Law of 1979 (Ross 1980).

The means of achieving privatization are partly found within the preceding discussion on institutional reform: revision of the forestry code, formal guarantee of tree ownership rights, reorientation of the forester from police to extension agent, and decentralization of regulatory and enforcement functions to the local communities.

10.52 Market system incentives. The use of market system incentives has been proposed by some as a way of stimulating (1) greater participation in reforestation by the private rural sector and (2) fuelwood conservation through improved production, utilization and consumption. Measures that fall under this proposal include:

* allowing the sale of seedlings--SODEVA (section 5.5) has used this policy for surplus seedlings produced in individual or collective nurseries; the possibility of evolving the PARFOB nursery into a regional facility is predicated, in part, on obtaining the authority to sell seedlings in order to defray some recurrent costs;

* attaching a market value on natural forest exploitation--this would involve a sort of "timber sale" by contract or auction, as opposed to treating royalties from charcoal cooperatives as a tax (Jackson et al. 1983);

* substituting market value for subsidized price of fuelwood--the current pricing policy on charcoal (30 FCFA per kilogram in Dakar, 1982) subsidizes the urban consumer at the expense of the rural producer; several analysts of this policy favor letting the price "float" to its market value.

The rationale behind associating a market value with hitherto "free, common goods," as in the case of natural forests, or with heavily or totally subsidized goods such as charcoal and seedlings is based on some interesting postulations. By affixing a "real" or "symbolic" (see SODEVA, section 5.5) price on seedlings, which traditionally have been distributed without charge to the population by the SWF, individuals or groups should be motivated to protect their investment by protecting planted trees. Second, revenues from the sale of seedlings can help cover some recurrent costs of the nursery operation and, therefore, contribute to its sustainability. Third, the diffusion of small nurseries, individually or collectively run, should provide better and more ample opportunities for the establishment of rural woodlots, again whether on an individual or communal basis.

The bias of the Master Plan strategies for forestry development in favor of plantation projects reflects a supply-side orientation. However, the problem of regional--and eventually national--fuelwood deficits must be also attacked from the demand side, in terms of promoting more efficient utilization, conversion and consumption of the fuelwood resource.

By treating the natural forests as a market rather than a free commodity and releasing charcoal from its unrealistically low controlled price, desirable results may occur. On the production side, there would be an incentive for better utilization (e.g., less wasted residues) and conversion (e.g., more efficient "Casamance" charcoal kilns) techniques as a response to the greater access cost to natural forests and the greater benefits from their product. On the consumption side, higher fuelwood costs would be unpopular but would encourage conservative use of fuelwood, prompting perhaps greater adoption of "Ban ak suuf" and other efficient cookstoves.

10.53 Self-policing. The Republic of Senegal has made considerable progress in administrative reform and decentralization of the decision-making structure. As pointed out in the discussion on "privatization," one prerequisite would be the decentralization of regulatory and enforcement functions, concerning the the forest resource, to the local communities. As Thomson (1983) noted:

> The current ineffectual system, which makes foresters solely responsible for woodlot policing, must be replaced by a system which secures popular cooperation in use control. Forestry policy must now gradually promote popular policing of resource use, and thus sustained-yield management. The job will only be done properly when rural Sahelians--ten thousand times more numerous than foresters--are given adequate incentives to police use of Sahelian woodstocks, and so effectively protect them.

In their analysis of customary and statutory laws concerning tree ownership and usage, PRECOBA (1982c) provided a very interesting insight:

> En ce qui concerne la protection des arbres naturels, il est fréquent que les représentants des populations se plaignent du gaspillage des maigres ressources encore disponsibles. Ces gaspillages procèdent généralement d'une exploitation commerciale frauduleuse effectuée avec la complicité de quelques villageois inconscients: carbonisation, bois d'oeuvre ou de service, etc....
>
> Les populations dans une très large majorité ont donc souvent souhaité qu'il leur soit permis d'organiser à leur niveau une certain forme de police forestière visant à réprimer ces exploitations clandestines et sauvages.
>
> Il ne serait pas contradictoire avec l'esprit de la réforme administrative, de désigner des éléments représentatifs de la population (chefs de villages, conseillers ruraux, etc. . .) en qualité d'agents commissionnés des Eaux et Forêts qui seraient des auxiliaires précieux du service forestier.

[Concerning the protection of naturally-regenerated trees, it is frequent that representatives of the population complain about the waste of the remaining scarce resources. This wastage is generally in the form of fraudulent commercial exploitation effectuated with the complicity of some inconscient villagers: charcoal, construction wood or timber, etc....

A very large majority of the population have often wished that they would be permitted to organize at the local level a certain form of forest police to address these clandestine and savage exploitations.

It would not be contradictory with the spirit of the administrative reform to designate representatives of the population (village chiefs, Rural Community Council members, etc.) as "commissioned agents" of the SWF who would be an important auxillary branch of the forestry service.]

Indeed, regulation and enforcement of tree ownership rights would seem to be a logical extension of the jurisdiction of the Rural Community in allocating and arbitrating usufructuary rights.

10.6 Natural Forest Management

The changing perception of natural forests from "useless brush with a productivity that hardly deserved serious consideration" to the realization that they should represent the heart of Sahelian forestry efforts has been driven largely by these rationales (Jackson et al. 1983):

* poor performance of large-scale plantations of "fast-growing" exotics;

* better understanding of the productivity of natural forests;

* greater appreciation of the wide range of important products, other than fuelwood, that flow from natural forests to the rural economy.

In Senegal, this realization is reflected in the Master Plan for Forestry Development (CTFT/SCET 1982a), which stated:

> D'une façon générale, la Recherche montre que l'aménagement des formations forestières naturelles, quand elle est possible, est de loin préférable aux coûteux reboisement.
>
> [In a general sense, research shows that the management of natural forest formations, when it is possible, is far more preferable than expensive reforestation.]

Despite this philosophical alignment with natural forest management, the Master Plan, as already pointed out, remains inherently biased toward plantation establishment, at least at the project level.

In Senegal, even if the rate of successful plantation establishment could be sustained at 10,000 hectares per year between now and the end of the century, the 200,000 hectares of plantation established by the year 2000 would supply only 15 percent of the national fuelwood demand (assuming a yield of five cubic meters per hectare per year and fuelwood as the sole end use) (Jackson et al. 1983). This means, of course, that the remaining 85 percent would have to come from natural forests.

The low yields of forests in the Sahel--e.g., 0.16-1.20 m^3/ha/yr in Senegal, 0.70-1.58 in Mali, and 0.35-0.50 in Niger (Clement 1982)--are largely attributable to their unmanaged and degraded state. Even in this state, there are many exceptions to the rough production estimates of one-half and one cubic meter per hectare per year for the Sahelian and Sudanian zones, respectively. As mentioned in section 2.34, preliminary results from sampling data in a nine-hectare block in the Bandia Forest indicated production rates ranging from 0.8 to 3.2 cubic meters per hectare per year (Freeman 1983).

Using a Visicalc computer program, CILSS has demonstrated that even at accelerated planting rates, regional fuelwood deficits would occur throughout the Sahel in the next five to ten years, given current trends of population growth and fuelwood consumption (Club du Sahel/CILSS 1983, Pierce 1983).

In the CILSS model, improving natural forest yield by one percent per year through management and protection techniques would result in a much greater positive impact on future fuelwood balancess than increasing the total area of productive plantations by 10,000 hectares per year. When a one-percent annual decline in per capita fuelwood consumption is also modeled in, the positive impact is even more dramatic.

In Upper Volta, it is estimated that increasing the yield of natural forests by 25 percent would be comparable to the yield from 500,000 hectares of plantation (Bailly et al. 1983).

What these simulations, flawed assumptions and all, indicate is that there are potential incremental yields to be realized through management of natural forests. For the moment, research priorities revolve around two questions (Jackson et al. 1983):

(1) What is the present productivity of natural forests?

(2) How can this production be increased?
--optimum rotation periods, protection against fire and grazing, silvicultural techniques;
--cost-effectiveness of these options.

It also appears that two types of interventions are possible. The first is the management of forest reserves; the second is the promotion of indigenous agroforestry practices, in which "anthropogenic forest parklands" are created by favoring certain species--for soil enrichment, food, fodder and other purposes--after clearing the remaining forest for cultivation. Although much research is still needed, relatively simple techniques (e.g., protection) exist that can increase forest productivity. The careful selection of pilot or demonstration areas, perhaps forest reserves near major urban centers, combined with effective extension would be one way to gradually put these ideas into practice.

The realization of a viable program of natural forest management will require much more than mere lip service. The experimental work conducted at the Bandia Forest, that being carried out at Ngueniene in the context of PRECOBA (section 5.1), and the PARCE (section 4.2) component devoted to large-scale experimental management of the Koumpentoum Forest Reserve are indications of the Senegalese commitment to this work. Needed now are the vision and the resources to sustain this commitment and to translate findings from the preliminary work into management options that can be systematically applied.

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