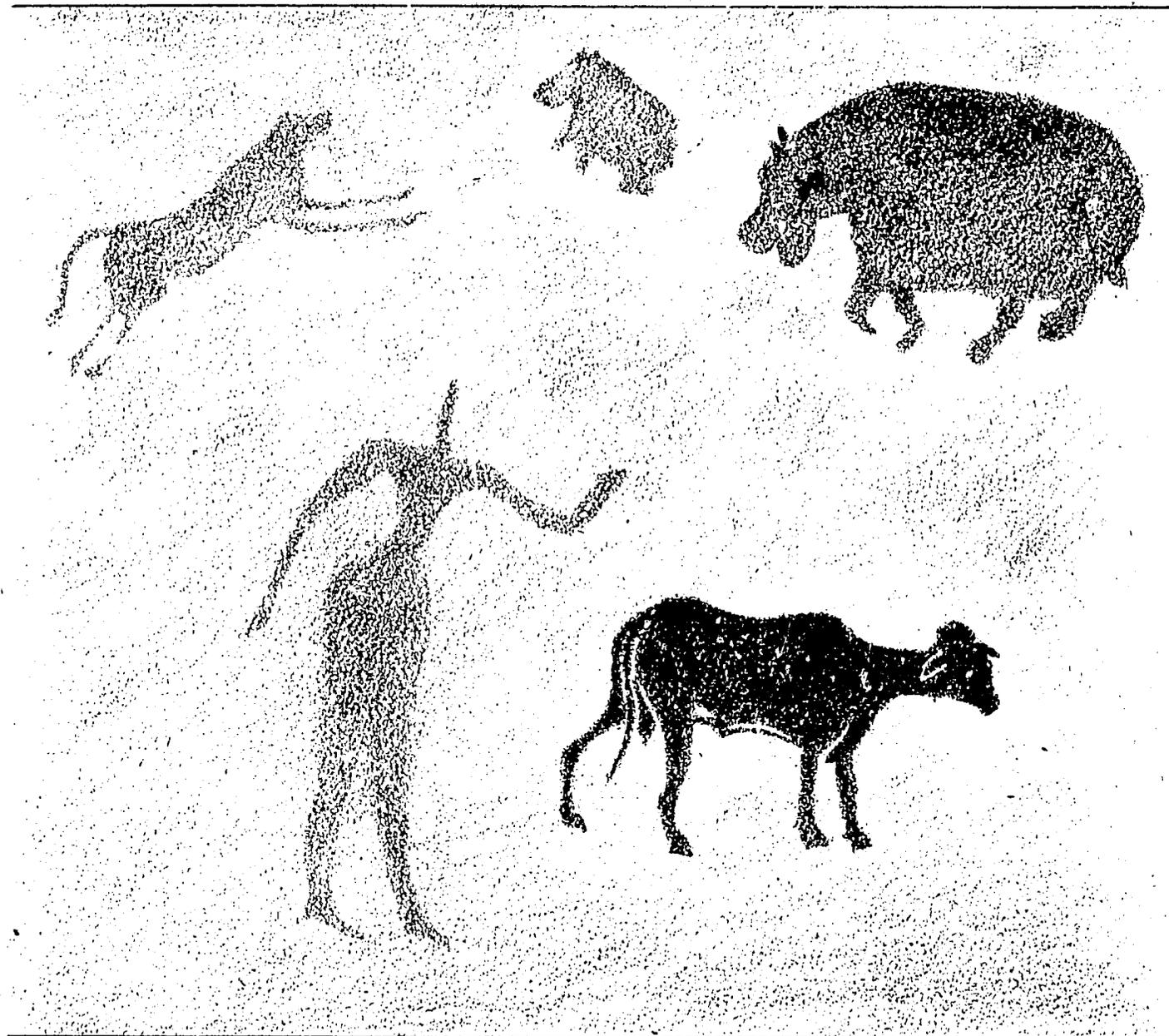


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MALI

BIOLOGICAL DIVERSITY ASSESSMENT



Peter Warshall

Office of Arid Lands Studies
University of Arizona
Contract No. AFR-0467-C-00-8054-00
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NATURAL RESOURCES
MANAGEMENT
SUPPORT PROJECT
(AID Project No. 698-0467)

Mali Biological Diversity Assessment

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Office of Arid Lands Studies
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BIOLOGICAL DIVERSITY ASSESSMENT: MALI EXECUTIVE SUMMARY



This report fulfills section 118/119 of the US Foreign Assistance Act. This act requires assessment of the importance of non-cultivated plants and wildlife — varieties, species and ecosystems (especially tropical forests) — to conservation and development strategies. Sections 118/119 try to insure that foreign assistance funds will maintain and hopefully restore and regenerate important biological resources within the nation receiving aid.

This is the first review of its kind ever written for Mali. For this reason, an extensive bibliography and many educational side-bars have been included.

PART I: THE STATUS AND MANAGEMENT OF BIODIVERSITY IN MALI

Mali's biological resources (vegetation and wildlife) have been hammered by the sixteen year Sahelian/Sudanian drought. At least 80% of the population depends on these biological resources for food security and income. Humans have suffered as well as non-human animal species and plantlife. Part I explains how the drought, biodiversity, and human economic production strategies intertwine.

Five ecological communities within Mali have special importance from the planetary, pan-African and national points of view. They are: the inner delta of the Niger River; the Gourma; parts of the southwest Sudanian woodlands; the Idrar des Iforhas; and the Sudanian rupicolous dry forests (Guibortia forests) of the western sandstone plateaus.

The Idrar, the Guibortia forests and the southwest Sudanian woodlands need biological inventories to determine what plants and animals remain, their population sizes and distribution. The southwest Sudanian woodlands support the northernmost population of chimpanzees in Africa; the endangered Derby's eland as well as many other birds and mammals. Smaller habitats such as the Saharan oases and riparian woodlands in southern Mali also need biological surveys. The inner Niger delta has lost its large mammals (the korrugum is extinct) and has low populations of crocodiles, manatees and hippos. It still supports over 1 million migratory birds (both intra-African and Eurasian) as well as important resident breeding birds. The Gourma supports the last remaining Sahelian and Malian herd of elephants as well as a wide variety of threatened antelopes.

Of these areas, only the Gourma has partial protection as a faunal reserve. All other areas described above have no official protective status. The Asango-Menaka faunal reserve protects giraffes which now number less than three. Other Asango-Menaka species have not been recently surveyed. The Boucle de Baoule National Park complex has lost its large mammals (elephants, Derby's eland, giraffe, buffalo, etc.). It has been invaded by groundnut growers, pastoralists, poachers, commercial and trophy hunters, and villages. A FAO team estimated that \$8 million US would be required to restore the integrity of the OFNBB complex, not including costs of reintroduction of the large mammals.

Although Mali could make a significant contribution to preservation and maintenance of Africa's and the planet's ecosystems, the GRM has not made conservation of natural areas a high priority. Commitment by the international community

has come in fits and starts. This report recommends: the upgrading of the Gourma to a national park; the creation of a Bafing/Faleme area national park; the protection of bird nesting areas in the inner delta; as well as the surveys required to make decisions on other natural areas. The restoration of the Boucle de Baoule may not be cost effective but should be considered. All of these proposals include long-term funding (eight to ten years), feasibility studies for boundaries and population distributions, conflict resolution with local villages, integration of local populations into national park economies or economic development assistance, building of tourist facilities, anti-poaching teams, and training.

Without significant financial aid by donors and political change by the GRM, there will be no significant large mammal populations left in Mali within five to ten years. The Saharan and northern Sahel regions have no protection. Addax, Dorcas gazelle and aoudad (barbary sheep) are threatened or endangered. The oryx is extinct. The slender-horned gazelle is probably extinct. In the mid/south Sahel and Sudanian woodlands, protection has been very weak. Most elephant herds, lion, Derby's eland, giraffe and ostrich populations are locally extinct and declining. Dorcas and Damas gazelles are rare. The cheetah and hunting dog have disappeared. All wetland species have declined from intense use of the floodplains, drought, hunting, fishing, and Manantali dam. These include the African buffalo, manatee, waterbuck, Buffon's kob, hippo, various fish species, and crocodiles. Three priority projects are: the Gourma elephants; the chimpanzees and Derby's eland (near or in the proposed Bafing National Park?), and the breeding waterbird sites, manatee, and fisheries of the inner delta.

Mali has no written flora and widely scattered plant collections. The Saharan oases have been largely replaced by non-native plantlife. Small recommended projects include: aid to the arboreta; assembling and cataloging the plant collections, surveying for relict *Guibortia* forests, and preserving some Sudanian/Guinean riparian forest.

PART II: CONSERVATION AND DEVELOPMENT

This section links food security and rural incomes to biological production and diversity. While Part I was concerned with "existence value," Part II focuses on "option value" (the value of maintaining a species or cultivar that might have economic value in the future); and "production" and "consumption" values (the economic value of wild plants and game meat to income). It reviews human actions that can hurt biodiversity and lower economic returns such as the secondary impacts of pesticides, fire, short fallow periods and over-browsing.

In Mali, animal resources are closely linked to subsistence, trophy and commercial hunting; tourism; agricultural pest control for cash crops; human disease control; fishing; livestock production, and river basin water management. Plant resources are closely linked to rainfed agricultural crops, drought fallback food, craft and medicinal plants, rangeland quality, cooking, home building and income from sedentary agriculture, agroforestry, timber forestry, agro-pastoralism, pastoralism, agro-fisheries, and artisans.

Subsistence hunting is a major source of protein for Malian households. The Code de Chasse does not recognize this fully and needs to be modified to allow seasonal hunting of small game such as warthog and francolin. Commercial hunting is not controlled. The DNEF does not have the manpower, equipment nor coopera-

tion of local hunter's groups to enforce any restrictions on commercial hunting. Many families supplement their income selling wildlife hides, skins and surplus meat. Mauritanian hunters extensively poach for jerky. A select group of commercial hunters sell wildlife parts or live animals to international buyers. Finally, trophy hunting for select rare species has contributed to the loss of biodiversity. The widespread poaching and the illegal trade in endangered species destroy Mali's biodiversity more than subsistence hunting of common small game. The GRM has been unable to control commercial and illegal trade and has been unwilling to close down markets selling animal parts. The GRM has occasionally issued permits for the rarest species. Government agents, diplomats, the army and DNEF have all been implicated in illegal game and trophy hunting. The GRM needs to set a better example if it desires to generate greater respect among all citizens for the Code de Chasse. Priority projects include: revising the Code de Chasse, establishing a revolving fund to stabilize pay to DNEF agents, donor-funding of an anti-poaching team, signing of CITES III by the GRM, a moratorium on special trophy permits, increased protection of rare species, cooperative efforts with Hunter's Associations to implement better game management practices, donor pressure on Europe to stop illegal imports of endangered species and reptile skins, and further research on the marketing of wild animal parts.

Pest control practices for birds, rodents, large mammals and insects have been reviewed. The SNPV has been careful and thoughtful in the use of pesticides and rodent control. More research on large mammal pest management (hippos and rice; elephant and gardens, etc.) is needed. A review of "target area" waterways that receive heavy doses of pesticides, fungicides and herbicides should be funded to assess both human health concerns and impacts on other species. SPNV needs a residue testing laboratory and assistance with the disposal of toxic chemicals. IPM has been minimal in Mali.

Mali has not developed its non-consumptive uses of wildlife such as photographic safaris and animal watching. Given Mali's cultural richness and the great multiplier effect of the tourist industry, "package" tours with a wildlife component could become a source of national income.

Non-cultivated plants contribute to "gathering" production strategies which provide drought-fallback nutrition, shelter materials, fuelwood, crafts materials, medicines, and supplemental income (e.g., from karite, palm mats). Those households without access to wild plants such as sedentary farmers suffer greatest in times of famine. Wild and weedy plants provide genes to improve cultivated crops such as rice, to maintain and improve commercial varieties such as karite, may possess "option values" as future medicines, and support other economic species (e.g., plants for insect pollinators). Mali does not have its own seed bank nor in-situ culture program for wild varieties. Both are highly recommended.

Non-cultivated grasses and browse plants are crucial in livestock management. Browse adds 30% of dry season nutritional intake. To restore drought degraded grasslands requires an intimate understanding of the seasonal importance of diverse plant species. The goal of economics and biodiversity is to replace annual grassland, dicots and weeds with more perennials and dry season shrubs. The heart of any anti-desertification and range restoration projects is the creation of nurseries that will grow and distribute browse and perennial grass species as well as the protection of secure, well-defined access and use rights to rangeland.

Biodiversity and agroforestry link: (1) at the species selection stage for nurs-

eries, windbreaks, alley crops, dune stabilization, forage crops, and soil improvement; (2) in management policies required to regenerate fallowed land; and (3) the understanding of the role of termites to ecological recycling. More than any other single project, the review of existing nurseries and the addition of new, especially native, species would greatly benefit both development and conservation.

Similarly, biodiversity and forestry connect: (1) at the species level in choosing species for reforestation projects; (2) in design of natural forest plans for timber; (3) in identifying the best methods and the most appropriate species for fuelwood regeneration. Surprisingly little is known about tree planting under existing forest canopies, rotation periods, nursery requirements and fire responses of West African tree species. This report stresses projects in Mali's southern natural forests and suggests candidate trees for further research.

The multiple impacts of fire on Sahelian/Sudanian zone plant and animal species as well as soil micro-biota are summarized. In Mali, the brushfire codes need revision to allow control burns in the Sudanian regions. The prohibition on burns in aquatic meadows and the Sahel should remain. A project to test Hier-naux's rotational fire policy in the Sudanian wooded grasslands is recommended.

The floodpulse of the Niger and Senegal rivers support both biodiversity and a large share of Mali's rural income. The floodpulse brings a "free" nutrient supply, irrigation water for recessional agriculture and grazing pastures, groundwater recharge, and increased fish, and waterbird and aquatic mammal populations. No aspect of Malian life binds biodiversity and economics so intimately. Three water projects influence the floodpulse: Manantali Dam, Selingue Dam and the Canal du Sahel. Manantali has had a negative impact on both the floodpulse-dependent economy and biodiversity. Projects to partially mitigate these harms have been outlined. The Selingue Dam may have a dampening influence on floodplain economies, fish and waterbird production. IUCN has suggested a project outlined in the Appendix to investigate the best multi-use release schedules for Selingue.

PART III: SOCIAL, POLITICAL AND ECONOMIC INCENTIVES TO MAINTAIN BIOLOGICAL DIVERSITY

Human activities can degrade and destroy or maintain and restore biological resources and diversity. Human actions and values can serve as positive incentives to maintain and to restore biodiversity; disincentives which warn, punish or frighten citizens, or perverse incentives which encourage destruction. These incentives, disincentives and perverse incentives can occur on any level: international treaties; national legislation; business contracts; trade agreements; decisions by judges or police; religion; community groups, etc.

Donors have not yet incorporated an understanding of the importance of species diversity and species composition into their funding. In part, it has not been fully appreciated that biodiversity concerns are more important to risk-avoidance, food security economics (which are largely non-monetary) than risk assumption, profit-oriented economics. The increased understanding of non-cultivated plants, small game protein and risk-avoidance economics contained in this report will hopefully help redirect donor funding. The PNLCD acts as a national umbrella program and legislative incentive in which to incorporate biodiversity concerns. Revision of various codes for hunting, brushfire, land clearing and forestry will remove some perverse incentives (such as the land clearing tax), decrease the need for

disincentives, and encourage incentives to protect species diversity. Economically, the GRM needs to return more of the profits made from the inner delta to the inner delta. At the moment, the economics work against sustainable development.

WALIA, an educational magazine in the Vth Region is the best conservation information for the public in Mali. It needs wider circulation. In addition, in urban areas, videos and movies are a high priority project to increase understanding of the importance of biodiversity and to encourage personal actions such as fuel-efficient stoves. A conference with Islamic leaders on conservation ethics and religion would serve as an awareness tool that can reach many Mallan citizens.

Finally, local implementation is the crux of all natural resource management. The structure of responsibility is, at present, confused. Customary, Dina, and post-independence rules are all active and, at times, conflicting. Secure access and use rights to water, fishing grounds, grazing areas, trees and hunting are incentives that can be traded for the proper maintenance of biological resources. Financing and training Malians in conflict resolution over questions of access and use rights are crucial components recommended in all biodiversity projects.

PART IV: PROJECT PROPOSALS AND US AID

Over 40 projects have been identified. For species and ecosystem preservation, the four priority projects are: the proposed Bafing National Park, the proposed Gourma National Park, and, if cost effective, the restructuring of the Boucle de Baoule. For combining economic development with biological diversity concerns, the writing of land tenure and resource management agreements for inner delta communities and the investigation of best management practices for Selingue Dam hold highest priority. Other projects such as the revision of national codes, the incorporation of biodiversity concerns into donor sponsored projects, the signing of CITES III, the collection and in-situ study of native cultivars and browse species, or conservation education projects are equally important. But, these smaller do not require the eight-to-ten year funding horizon required by the priority projects.

Over the next five years, US AID is not in a financial position to contribute to the priority projects, unless the Mission finds substantial fallout funds. Biological diversity concerns are not a high priority for the mission. In addition, their geographical focus limits the nature of project participation. Nevertheless, the Mission's concern with locust control, pesticides, family planning, mother/child nutrition (and drought fallback foods), and one reforestation project show some budding interest. Biodiversity can be added to new projects on livestock research and agricultural policy reform for rainfed agriculture. Through policy dialogues, the Mission should continue to help and influence other contributors such as the World Bank, OMVS, and IUCN. The Washington Bureau may be able to fund smaller technical aspects of some of the recommended projects. The Peace Corps has shown interest in many aspects of this program and will, perhaps, become the main US implementor of biodiversity in Mali.

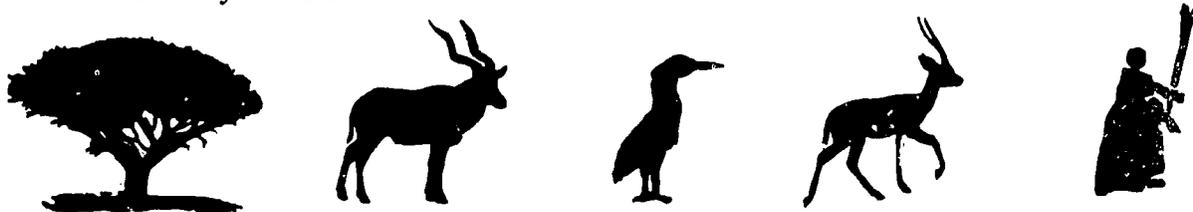


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LIST OF ABBREVIATIONS

ADB	African Development Bank
CDSS	Country Development Strategy Statement
CILSS	Permanent Interstate Committee on Drought Control (Fr)
CITES	Convention on the International Trades in Endangered Species
CPS	Crop Protection Service (SNPV in Fr)
DANIDA	Danish International Development Agency
DNEF	Water and Forestry Department (Fr)
EEC	European Economic Community
EPA	Environmental Protection Agency
FAA	Foreign Assistance Act
FAO	Food and Agriculture Organization
GRM	Government of the Republic of Mali
IBPGR	International Board for the Protection of Genetic Resources
ICRISAT	International Center for Research in Semi-Arid Tropics
IDA	International Development Association
IER	Organization for International Economic Relations
ILCA	International Livestock Center for Africa
IMF	International Monetary Fund
IPM	Integrated Pest Management
IRRI	International Rice Research Institute
IUCN	International Union for the Conservation of Nature
OCLALAV	Organization to Fight Grasshoppers and Aviary Pests (Fr)
OHV	Operation Haute Vallee (will be ODV in 1989)
OMVS	Senegal River Basin Authority (Fr)
OPNBB	Organization for the Boucle de Baoule National Park Complex (Fr)
OPSR	Swiss Farming Systems Research Project (Fr)
ORM	Operation Riz Mopti
ORSTOM	Office de la Recherche Scientifique et Technique d'Outre-Mer
PNLCD	National Plan to Fight Desertification (Fr)
PVO	Private Voluntary Organization
RAMSAR	
SAFGRAD	Semi-Arid Food Grains Research and Development
ULV	Ultra-Low Volume (pesticide usage)
UNESCO	United Nations Educational, Scientific and Cultural Organization
USDA	United States Department of Agriculture

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BACKGROUND

The biological resources of Mali are a form of natural capital — capital in which 90% of the nation's population actively participates. The biological resources can be found on three scales: genes or germplasm, species or races, and ecological communities. The variety of these biological resources are sometimes lumped together under the rubric "biological diversity" or "biodiversity." This report will assess Mali's biological diversity.

Although Mali's biological resources can be considered a "free" gift of nature, they are neither inexhaustible nor completely renewable. Genes, species or ecological communities can go extinct and be lost forever. Ecological communities can degrade so severely that they cannot recover for hundreds of years. To maintain nature's gifts requires a four-pronged effort:

- preserve sample ecosystems and species so they become part of the national and educational heritage ("existence" value) as well as tourist potential ("non-consumptive use" value).
- preserve sample populations of wild foods, medicinal plants and other useful species for possible use in new or expanded forms of production ("option value");
- maintain existing biological resources and variety in order to keep ecologically dependent production (e.g., fisheries, forestry, wood products, livestock and rural farming) at current or increased levels ("production" and "consumption" values);
- regenerate degraded biological resources in order to increase ecologically dependent production, consumption and non-consumption use economies.

The preservation, maintenance and regeneration of biodiversity in Mali is difficult. The nation has suffered from a sixteen year drought that may continue. Since independence, it has undergone almost three decades of social upheaval, struggling for a new balance between short-term needs and long-term sustenance. This report can point to very few successes. It points to a long hard road for both the Government of Mali (GRM) and donors concerned with biological resources and diversity. The Malians interviewed all understood these difficulties and showed an admirable honesty in their analysis. The farmers, fishermen and pastoralists reflected the strong resilience of the Sahelian peoples in the face of the second worst drought of this century.

This report can be used in various ways. It is the first summary Mali's biological resources(34). As such, the report is both an educational and awareness tool. Understanding this, US AID has funded its translation into French. I have included an extensive bibliography since no other bibliography currently exists.

The report is also one of the first African reports written under Section 118 and 119 of the US Foreign Assistance Act. As such, it can serve as a model for other reports. It includes sections not seen in other biodiversity reports(e.g., biodiversity and large mammal pest control, browse species diversity in rangeland management).

The report also contains a list of over 40 projects with a biological diversity component. The list serves as a "shopping list" for donors and the GRM. Although only briefly described, these projects have been carefully reviewed with the DNEF,

donors, and research workers. They all merit attention.

Finally, the report serves as the basis for a policy dialogue between donors and the GRM. The goal of this dialogue is the writing and implementation of a comprehensive National Conservation Strategy for both conservation and development.

OUTLINE OF THE REPORT

Part I will address: What do we know? What happened to biological diversity during the sixteen year drought? What varieties, species and ecological communities in Mali are unique on the planet Earth? What aspects are uniquely important to Mali? What priorities should be placed on these biological resources from the planetary and national viewpoints? How well are they protected now?

Part II will address: How are the economic production systems of Mali connected to biological diversity? What aspects of biological diversity might help increase production and income in the near or distant future? What aspects of biological diversity need regeneration in order to increase production and help food-security?

Part III will discuss: How do we do it? How do they promote or discourage the maintenance of biological diversity? Is it financially or politically possible to save species or communities of concern? What kind of incentives might add biological diversity into natural resource management and development projects? What administrative, technical, economic and educational problems exist in Mali.

Part IV will describe projects that I feel should have the highest priority. Given US AID's budget and primary goals, what projects might realistically be of interest?

TIME, PERSON-HOURS AND EFFORT SPENT

This report satisfies the congressional mandate (Sections 118 and 119 of the Foreign Assistance Act) on biological diversity and tropical forests. But, no report can give equal detail and emphasis to all aspects of biological diversity. The subject is too extensive and no mission or Washington Bureau has the finances required to research and write such an exhaustive study.

This report was completed on a five week contract in November/December 1988. The single author spent three weeks interviewing ministries and agencies, collecting background reports as well as making two very short trips into the field. Two weeks were allocated to write the report. Some material had been collected during a three-day field trip to the inner delta on a previous consultancy in 1987. The Environmental Officer (February 1988) in Abidjan requested that a Malian consulting firm collect the background material on biological resources of Mali. The compilation never occurred. The shortage of information and person-hours meant that certain biological resources (eg, fish, wild plant seed collections, possible Guinean forest localities in the extreme south) have received only cursory attention.

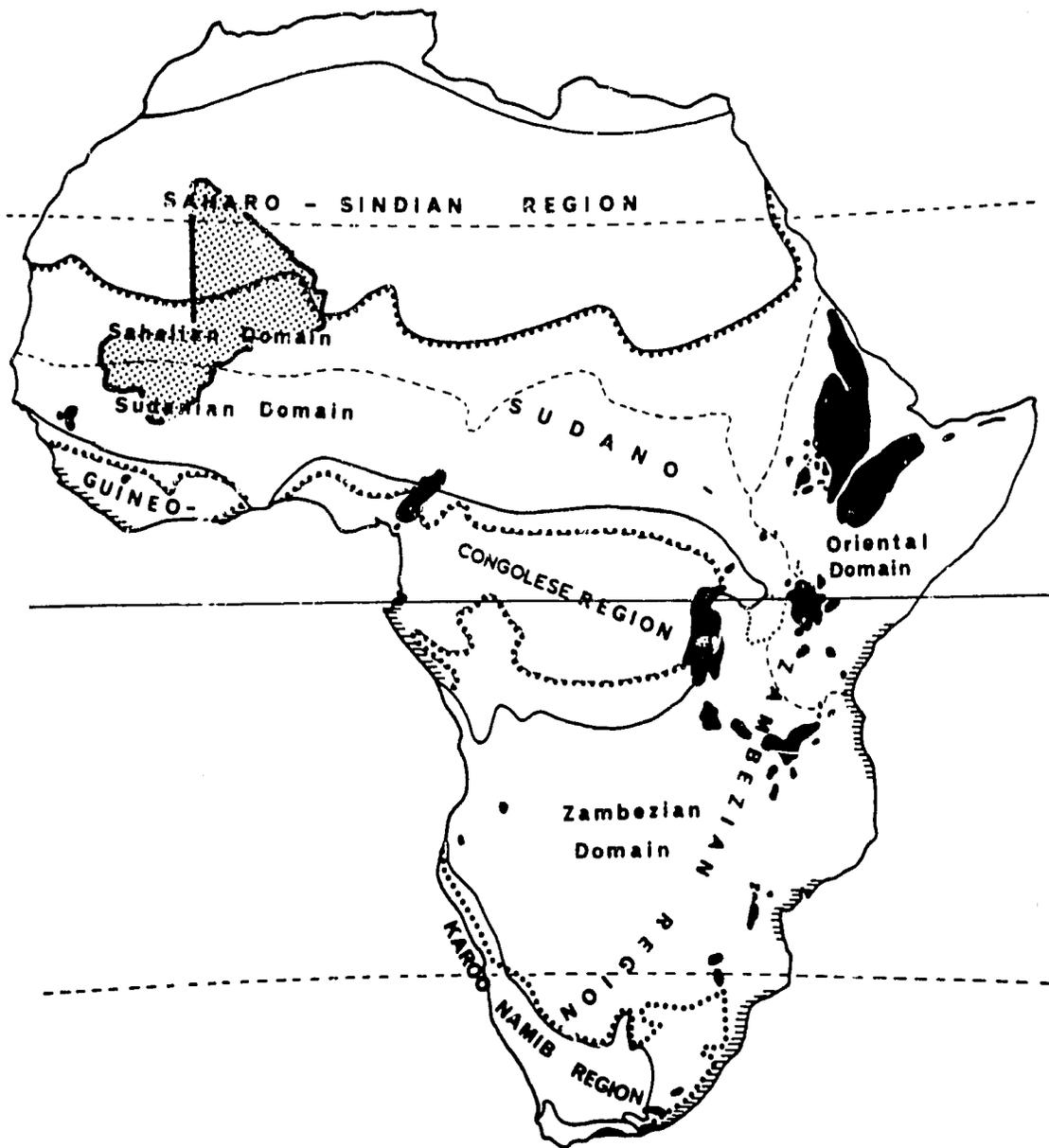
ACKNOWLEDGEMENTS

The complete list of all those who kindly gave their time can be found in the "Persons Contacted" annex. I would like to single out the great help of Mana Diakite who guided me throughout my visit. Mission Director Dennis Brennan and Tracy Atwood (ADO) took special interest in encouraging this report. Many staff members of the mission went out of their way to obtain hard-to-find documents. Dennis Billodeau kindly arranged my trip to Manantali Dam. The report would not have been possible without the vigorous support of Dwight Walker in Washington. Richard Moorehead, Susanna Davies and Monique Trudet twice provided huge amounts of time and hospitality. The unreferenced artwork is by Patrick Suïro (19) and Paul Mirocha. Cover by Paul Mirocha. Page design by Julie Tronson.

BIODIVERSITY: TWO CLARIFICATIONS

In discussing biodiversity issues in the US and Africa, certain consistent misunderstandings arose. First, biological diversity is not the same as natural resources management. For instance, a farmer can improve his soils and crop production without becoming involved with biological diversity. Biological diversity focuses on a small area of complete natural resources management. It can be an important component as explained throughout this report. But, to be called "biodiversity," the manager must be able to point to varieties, species or ecosystems that need help and will benefit from management. Maintaining populations of Senegalese long-tailed parrots in millet farms is not a goal of biodiversity management. Designing a pest control program that maintains some populations of parrots but also reduces millet losses is a biodiversity goal.

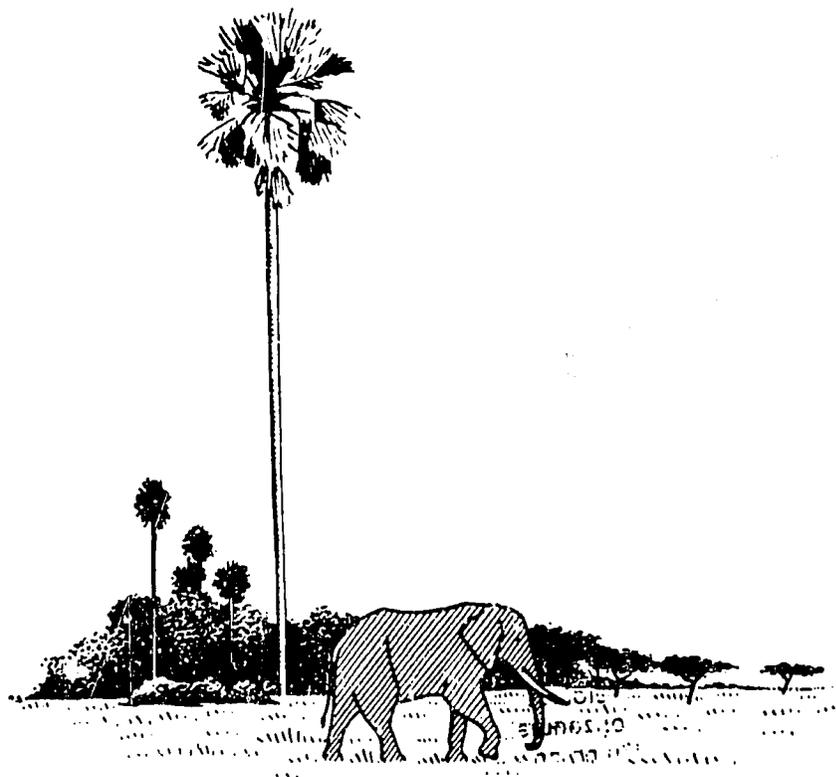
Second, biodiversity does not necessarily try to preserve the maximum number of species. Because the term was born with thoughts about tropical rain forests, this is often a confusion. Some areas of the Sahel have relatively few species. The goal of biodiversity is to maintain all the pieces of the Sahelian ecosystem so that the food web will not deteriorate. This means maintaining pollinators as well as the plants they pollinate; browse shrubs as well as the gazelles that eat and disperse the browse shrub's seeds; the microbial soil community as well as the soil; the fish as well as the crocodiles that control their population size. If the reader keeps the food web rather than species numbers as the primary focus, then this confusion never arises.



Mali's Position in African Biogeography
(Source: 10)

PART I:

STATUS AND MANAGEMENT OF THE PRESERVATION OF BIOLOGICAL DIVERSITY



WEST AFRICAN ELEPHANT (*Loxodonta africana*)

Ten years ago, there were four small populations left in Mali. The Mauritania/Boucle herd, the Faleme Valley/Mandigue mountain herd (Senegal/Guinea/Mali), and the Sousan herd (Mali/Ivory Coast) are now considered extinct or no longer viable. Only the Gourma (Mali/Burkina Faso) herd remains and it is declining. In 1982, 600 elephants were reported. By 1988, there were only 400 elephants and some observers say that there are no more than 200. (The Gourma "herd" is actually a series of herds, leading to confusion.)

Drought mortality, competition with livestock, displacement by sedentarized pastoralists, poaching, unknown reductions in Burkina Faso, and habitat destruction have contributed to this decline. The local Tamasheq would like to preserve the elephants.

The Gourma elephants are Mali's only herd and the most viable northern elephant population in West Africa. They move more than any other herd recorded (800 km) in Africa and are the only herd known to visit the Sahel. One estimate states that the elephants need 33,000 km² because of the arid habitat. They are among the highest priorities of the IUCN Elephant committee. They need emergency attention. A project proposal can be found in Part IV.

A. BIOLOGICAL DIVERSITY AND THE DROUGHT

The sixteen year drought in the Sahel has left an indelible mark on the biological resources and diversity of Mali. The economy and lives of its citizens have gone through an irreversible shift. Terms of trade, job opportunities, community organization of labor, rules of access and use of natural resources will never be the same. An exhaustive review is impossible. Here are consequences of the drought on biological diversity, inseparable from the livelihood of Mali's citizens.

— Before the drought, transhumant and nomadic herds penetrated northward. The herds grew in size and the more attractive grass species (*Schoenfeldia*) became very rare, while more weed-like species (*Cymbopogon schoenanthus*) proliferated. Unappetizing *Euphorbias* and little eaten *Aristidas* replace staple grasses (that even humans consume) such as *Digitaria guayana*. During low rainfall years, herds concentrated on remaining pastures. Vegetation cover diminished. Close grazing crushed seedlings, compacted soil, and prevented regeneration. The intense churning of soil by hooves uprooted grass tufts and the wind swept them away. During these dry periods, there is less rain but it falls in more intense storms. On slopes, the finer soil particles ran off with the water. On drying, the winds took away the finer silts and sands. The increased albedo further prevented seed germination and seedling survival by increasing surface heat.

— In a vicious spiral, pastoralists began to graze too soon or too long preventing perennials from storing enough energy in their roots and preventing long-cycle annuals from maturing to seed. Perennial plants or annual plants with a long vegetative cycle disappeared from over-grazing and too little rainfall. The actual numbers of species (pre- and post-drought) may be approximately equal but the new dominants are annual plants with short vegetative cycles — that is, species that can evade the animals who actually need them during the period of nomadic or transhumant grazing.

— In some places, the reduced grass cover helped trees by allowing more water to infiltrate to the trees' roots. In other places, herders switched from cows to goats and cut branches off trees and shrubs for their livestock. Eventually weakened, the trees died. In still other areas, a crust of algae replaced the grassland (the last attempt at life on the Sahelian surface). The crust sealed the surface from infiltration and trees died of partial thirst or runoff increased erosion around their roots.

— Trees such as *Acacia nilotica* disappeared because groundwater tables sank in some places as much as 75 feet. Women had a harder time drawing water from wells and keeping their gardens.

— The regeneration of pasture and browse became more difficult. Woodland and grassland became fragmented and transformed into islands. Groves of scattered trees could not be pollinated as well by wind or insects. The population of insect pollinators shrunk. Seed stocks in the soil decreased.

— In areas abandoned by livestock and depleted of antelopes, the regeneration of shrubs and trees diminished. Many of the tree and shrub seeds need to pass through the stomach of ruminants to germinate. Birds no longer visited fragmented woodlands reducing seed dispersal still more.

— The shrinking of the inner delta of the Niger meant less floodplain agriculture, less floodplain pastureland, and less water for fish breeding, fish production and food and shelter for other aquatic animals (e.g. manatees). The shrinking of available surface water and reduced food stimulated an increased interest in hippo and manatee meat as well as crocodile skins. The food shortage intensified the gathering of wild foods such as wild rice and water lilies. Over-exploitation of both plant and animal wetland species as well as reduced flooding shrunk available harvests, sometimes to nothing.

— Brushfires diminished in the north as biomass production dropped below 1000 kg DM per hectare. However, they increased on aquatic meadowland. They escaped controlled burns more easily and more often in the Sudanian wooded grassland. At times, farmers tried to increase yields by burning. This short-term gain meant long-term losses in organic matter, nitrates, and overall fertility. An unknown amount of wood was wasted by these burns.

— Cows produced less milk and gained less weight. Reduced dairy and meat production forced pastoralists, fishermen, and farmers to search for other sources of cash to purchase grains. Many supplemented their income by selling firewood — increasing albedo (loss of canopy cover), erosion (loss of litter and roots), an organic matter (the tree was exported). Others harvested palm leaves for thatch or mats. Rural citizens harvested all drought fall-back plants heavily — just when the plants were under most ecological stress.

— Drought exacerbated the difficulties in maintaining wildlife. As graze, browse and seed resources as well as wetland insect populations plummeted, the species higher up on the food chain suffered. Survival of the young and litter and clutch sizes decreased. Bushmeat became a more valuable strategy for food security. Conflicts between starving baboons and other wildlife that raid crops became more intense. Ungulates searching for watering places became easier targets. They competed for greatly diminished pasture and browse. Increased fire reduced shelter and protection of grassland and woodland species as well as hurt snakes, frogs and birds dependent on the grasslands moister micro-climate (see Part II. C). Mercantile poaching (poaching for profit) became more widespread.

— Locust populations decreased temporarily removing the threat of plague. *Quelea* populations decreased, but golden sparrow populations increased. Jackals, hyenas, rats, squirrels, hares, francolins and other "generalist" species that profit from cleared land increased. All other mammals, reptiles, birds and fish decreased.



From the point of view of Mali's plantlife, four aspects of "desertification" are biodiversity issues: reduction of total vegetation cover; stunting of perennial plants; elimination of organic matter from the soil by leaching or erosion (loss of soil microbial and invertebrate populations); and disappearance or replacement of plants capable of remaining alive for a few months by less useful plants which mature and die in only a few weeks.

For wildlife, the drastic loss in numbers and even some extinctions require a reduction of hunting pressure until the populations can recover and become viable.

For humans, the drought has meant a new look at land tenure, tree tenure, pasture and water rights and a full realization of the need to reconcile confusing traditional, Dina, colonial and post-independence rules. Drought-adapted crop varieties and wildfood species are no longer a luxury. Native plants are no longer just gifts of God but plants that may require nurseries and re-planting. Understanding the role of each grass species and browse species in savopastoralist ecology is a matter of future survival. Protecting wildlife, including fisheries, is also protecting drought fall-back food security. The human ecology of biodiversity is now a critical factor in both sustainable economic development and resource conservation.

B. BIOTIC COMMUNITIES AND BIODIVERSITY

B.1 Preservation and Management

In a nation like Mali, it is necessary to carefully consider each proposed area for preservation and management. Because of limited financial capabilities and the drought, the number of areas will be few. To choose the most important areas to protect requires:

- * a description of all remaining relatively intact habitats;
- * their distribution (size and scatter; distances between these habitat "islands");
- * a description of the linkages (drainageways, river crossings, mountain passes, valleys, wetlands) which might, by acting as safe-passage corridors, increase effective size; and
- * a description of potential dangers to species within the corridors or landscape matrix that surrounds the protected area.

In Mali, no protected area is an isolated piece of habitat. The landscape immediately surrounding protected areas must be considered and buffer zones with special rules enacted. The ultimate goal must be integration of the local economies and assignment of land stewardship responsibilities to the local populations. In Mali, with a colonial tradition and Islamic tradition of hunting reserves (not animal sanctuaries), the Forestry agents will never accomplish protection and management without local cooperation and help.

Finally, to achieve government/local cooperation, each protected area requires resolution of all access and use conflicts that prevent biodiversity maintenance (eg, poaching, over-fishing, brush fires). The funding for a "facilitator" to resolve conflicts is crucial.

B.2 Status of Knowledge

Mali is a large nation — the size of Texas and California combined. Ecologically, it has been divided in many ways. In this report, I use Monod's classification (page 4) because it includes both genetic (evolutionary) history as well as present-day climate/plantlife associations. The three main divisions within Mali are the Sahara-Sindian, Sahelian and Sudanian domains.*

The Sahara-Sindian Region shares an evolutionary development with Arabia, Iran and India. Mali covers sections of the western and southern **Saharan domain**. The Sahara has from less than 500 species (absolute desert) to about 1,000 species (in areas >200 mm rain bordering the Sahel) in any 10,000 km² area. (There are about 1600 total plant species.) When there is rain, the Malian Sahara receives monsoonal (summer) rains. The Malian Sahara shares many of its major vegetation types (desert dunes with perennial or annual grasses; oases; regs, hamadas and wadis; absolute desert) with Mauritania, Algeria, Niger, Libya, Chad. There are very few endemic plant genera (about 16) — plant groups unique to a domain or region. They are mostly northern. The southern Sahara is too closely tied to the Sahel and tropics to support many endemics. The Saharomontane endemics of the Idrar, if they exist, are not known.

The Sudano-Zambezian Region wraps around the rainforests of the Congo (map, page 4). It has two subdivisions in Mali: the Jahel and the Sudanian regions. The **Sahelian Domain** cuts clear across Africa from the Atlantic to the Red Sea. Its vegetation has ties to the whole of the Sudano-Zambezian Region as far as South Africa with smaller links to Asia and the Somalian-Masai (aka "Oriental") Domain. There are about 1200 species of plants (500 - 1500 species per 10,000 km²) with only about 40 truly endemic plants. Mali shares semi-desert grassland and shrubland with Mauritania, Niger, Chad and Sudan; and Sahelian Acacia wooded grassland and deciduous bushland with these same nations plus Senegal.

The **Sudanian Domain** has about 1000 to 2000 species per 10,000km² and probably no more than a total of 2750 species of plants throughout. About 900 are endemic (found pretty much nowhere else). Other species can be found in most of the dry parts of Africa and some throughout the tropical regions of the planet. The Sudanian Domain wraps around the Congolese rainforest but tapers off in Sudan and Uganda. It is mostly woodlands with secondary grasslands. Fingers and islands of forest encroach into the Sudanian Domain from the south. The Sudanian wood-

*By climate, Mali can be divided into arid, semi-arid and sub-humid zones. By plant forms, the most common and useful classification has been the Yangambi classification into woodland (foret claire), savanna (savane) and steppe (steppe). The savannas of Mali include grass savannas (savane herbeuse), shrub savanna (savane arbuste), tree savanna (savane arboree). The steppes of Mali include the tree or shrub steppe (steppe arboree or arbustive) and the grass and/or herb steppe (steppe herbacee et/ou graminee). In addition, there are wetland types of importance (Table 1-2). White (11) and Menaut (10) have written the most complete recent discussions. Weber (60) compares French and Anglo systems.

lands (page 4) cut through fourteen African nations from Senegal to Ethiopia.

From the planetary point of view, the most unique ecological communities and the ecological communities that contain the most intact food webs include:

- The Inner Niger Delta — the largest wetland in West Africa and one of the most important to all of Africa (see Box).
- The Idrar des Aforhas — a higher elevation biotic community with ties to both the Sahara and the Sahel.
- The Gourma with the last Sahelian herd of elephants, other threatened Sahelian wildlife as well as important inter-dunal marshes.
- The Sudanian woodlands in the southwest with a significant center of Sudanian endemics, especially primates and ungulates.
- The Sudanian Dry Forests of Western Sandstone Plateaus with unique relict forests relatively untouched by the thousands of years of human influence.

TABLE I-1: VEGETATION AND SOILS (SOURCE: WEBER, 60)

ZONE	SUB-AREA	MEAN ANNUAL RAINFALL (in millimeters)	GRASSES	BUSHES & TREES	SOILS
SAHEL	 GRASS STEPPE	0-200mm	<u>Salvadora</u> <u>Leptadenia</u> <u>Aristida</u> <u>Panicum</u>	<u>Acacia radiana</u> Some <u>Balanites</u>	Undifferentiated soils: less than 30cm deep; sub-desert sands in hot dry climate -- often rich in carbonates and soluble salts.
SAHEL	 TREE STEPE	200-500mm	<u>Aristida stipoides</u> <u>Cenchrus ciliaris</u> <u>Schoenfeldia gracilis</u>	<u>Acacia</u> <u>Commiphora</u> Some thickets	Brown Soils: Highly saturated non-kaolinitic clays; fairly fertile but dry.
SAVANNA	 SHRUB SAVANNA	500-900mm		<u>Acacia nilotica</u> <u>Terminalia</u> <u>Anogeissus</u> (lower locations) <u>Acacia albida</u> <u>Hyphaene thebaica</u> <u>Gulera senegalensis</u> <u>Annona senegalensis</u> <u>Ziziphus</u> <u>Bauhinia</u>	Ferruginous Soils: Begin here often contain impermeable layers of iron oxides. Outcrops form "cuirace". SiO ₂ /Al ₂ O ₃ ratio around 2. Cation exchange capacities rather poor. Free carbonates are lacking, but free iron oxide is common. Range: 500-1200mm rainfall (See also Wooded Savanna) Fair Fertility
SAVANNA	 WOODED SAVANNA	900-1200mm	Thick, tall grasses	<u>Terminalia</u> <u>Euryprosperum</u> <u>Parfia</u> <u>Morassus</u>	Ferruginous Soils: See "Shrub Savanna".

TABLE 1-2: BIOTIC COMMUNITIES OF MALI ACCORDING TO WHITE (11)

A. Saharan Regional Transition Zone

- Oases
- Wadis
 - Tamarix communities
 - Acacia communities
 - Hyphaene (Dour) communities
- Psammophilous vegetation
- Regs
- Saharomontane vegetation
- Halogypsophilous vegetation
- Absolute desert

B. Sahelian Transition Zone

- Sahel Wooded Grassland
- Sahel semi-desert grassland and transition to Sahara
- Sahara
- Sahel deciduous bushland*
- Sahelomontane Scrub Forest*
- Sahelomontane Secondary Grassland*

C. Sudanian Zone

- Sudanian Dry Forest (Gilletiodendrum or Guibourita)
- Sudanian Riparian Forest
- Sudanian Transition Woodland
- Sudanian Woodland
 - Sudanian Isoberlinia and related woodlands
 - Undifferentiated Sudanian Woodland
- Sudanian Grassland
 - Sudanian edaphic grassland and wooded grassland
 - Valley and Floodplain Grassland
 - Grassland and Other Herbaceous Communities on shallow soil over ironstone (howal).
 - Secondary Sudanian grassland (around villages)
- Sudanian Rupicolous Scrub Forest (Guibortia)

D. Herbaceous Freshwater Swamp and Aquatic Vegetation

- Permanent Lakes
- Open backwaters
- Shaded backwaters
- Permanent River Channel
- Tributary Channels (sandy, clayey, rocky)
- Floodplain pastures
- Floodplain marshes

ECOLOGY OF THE INNER DELTA



NOVEMBER: Flood peak and decreasing rains. Lateral spread of fisheries as lakes connect to main river.



APRIL: Grasslands grazed. No rain. Lakes isolated from main river.

The inner Niger Delta in Mali's Vth Region is the most important area for rice growing, fishing, and grazing in the nation. 500,000 citizens depend on this rich wetland ecosystem which at its flood peak can cover 30,000 km². The sketches (left) show how the floods arrive as the rains diminish providing a prolonged season for biological production.

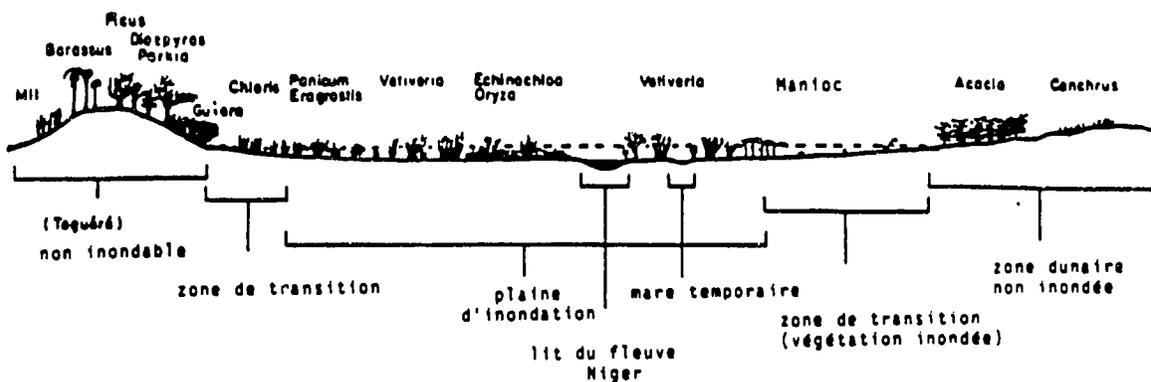
The postflood pastures of the delta provide dry season range for about a million cattle and a million sheep and goats. The delta is the key ecological and economic resource in the annual cycle of transhumant pastoralism. Productive pastures and watering would otherwise be lacking. The export of beef, hides and skins and transhumant food security (by trading milk for grains) would be impossible.

80,000 fishermen depend on the flood. In 1986, the catch was approximately 40,000 tonnes with exports of smoked fish as well as local sales. Agro-fisher and transhumant fisher families could not survive without the delta's bounty.

The natural production of wild grains (particularly "bourgu," *Echinochloa stagnina*, and water lillies) provide crucial drought fallback food, seasonal grains before the millet and rice harvest as well as sources of supplemental income in normal years. The harvests from recessional agriculture from the production of rice, millet and manioc are completely dependent on the flood's height, area and duration. The bottom sketch shows a cross-section through a narrow part of the delta.

The economic importance to the delta's five main production groups (agro-fishers, agro-pastoralists, transhumant pastoralists, transhumant fishers and sedentary farmers) supports an additional economy of trade and export. Since 1972, donors and the GRM have spent over 112 million US dollars in the development of the delta's agricultural, pastoral and fishing economies.

In addition, the delta is one of the three largest in all of Africa. Until recently, it was a major wonder of wildlife and subsistence hunting. Now, very few mammals remain. Only a few hippos and manatees find refuge. On the other hand, over two million migratory birds of 110 species still come to the delta in the non-breeding season. These include both Eurasian and intra-African species. The delta supports over 100 species of fish.



B.3 Areas Protected

Mali has two classes of land protection that protect all biological resources. "Reserves naturelles integres" does not allow any use by humans without permission of the Director of DNEF, including camping or tourism. All natural factors are allowed to play at their will. "Parcs Nationaux" are similar, but buildings, fire control, roads and other management activities can occur. There are no "reserves integres" in Mali and only one national park (the Boucle de Baoule complex, OPNBB). The other reserves are partial for specific species (Section B.4) or controlled forests.

B.4 Effectiveness of Protection

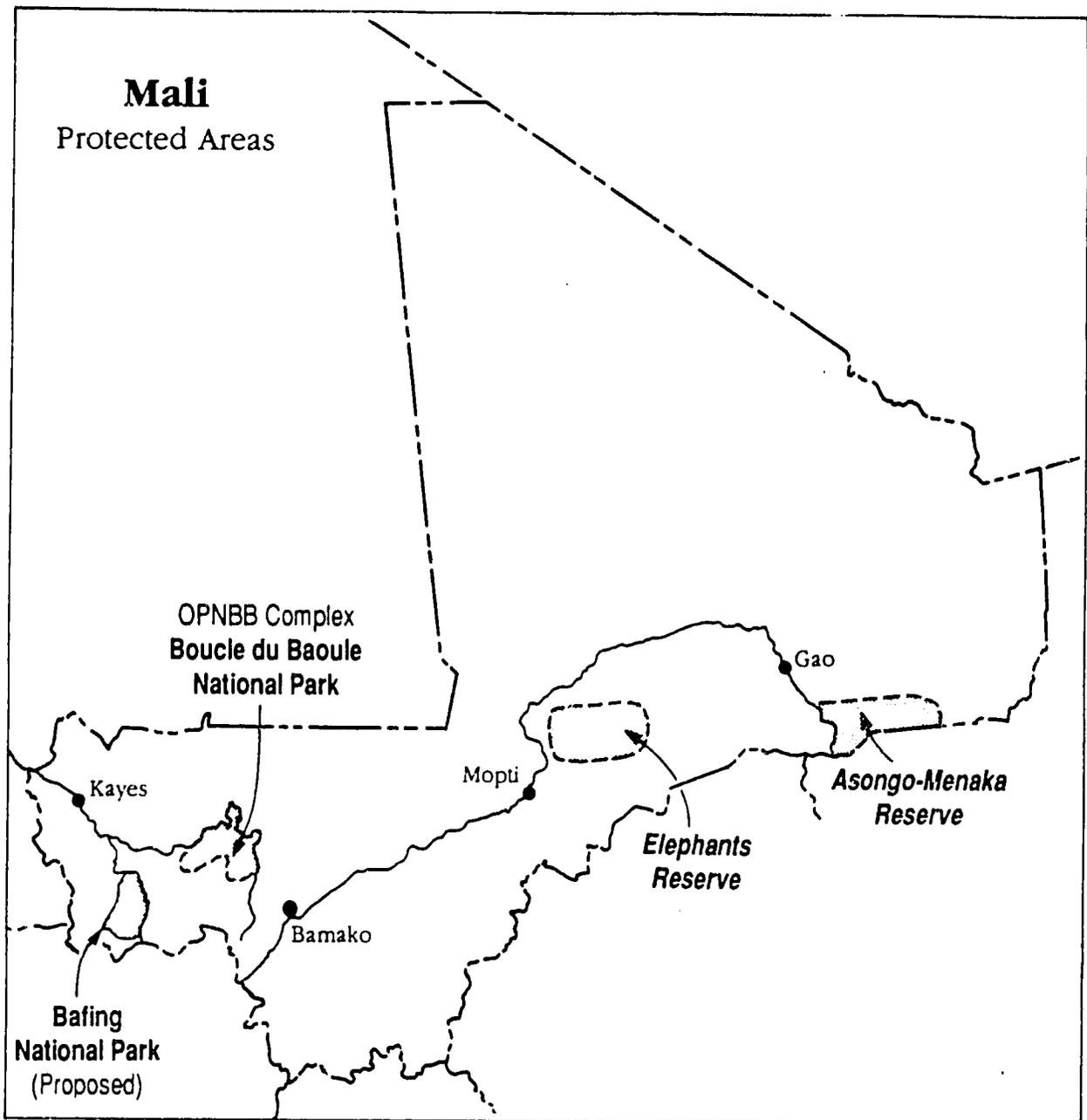
For historical reasons, the GRM has not given ecosystem protection a high priority. Only the recent drought has made the GRM aware of the need to maintain islands of intact habitat. The value of intact ecosystems as "national treasures" or sources of educational, national pride or tourist income has not been widespread.

The only attempt at ecosystem protection was the establishment of the Boucle de Baoule National Park in 1982. This park was made into a Man and the Biosphere Reserve by UNESCO. But, between 1982 and 1988, groundnut growers, transhumant pastoralists, Mauritanian poachers, Bamako hunters, firewood cutters, and sedentary farmers invaded the park and the forest reserve lands adjacent to the park. The DNEF has not had the man-power, the military strength nor the strong support from the upper levels of the GOM to prevent this degradation of the park and its surrounding forest reserves. Several large mammal species are now extinct within the OPNBB and many are threatened. A recent FAO report said a minimum of \$1 million US for five to six years would be needed to stabilize the situation (74). Since the GRM does not have this level of financing, it will be the international community that decides if the Boucle is an important priority compared to other possible protected areas in other nations (see Part 4 and Appendix).

B.5 Areas Outside Protected Areas Requiring Protection

Most of West Africa has a long history of human use. The oases have been planted with date palms. The Sudanian and south Sahel frequently burned. The southern woodlands harvested for timber. Where possible, the land cleared for farm and fallow agriculture. There is a world of difference between the idealized maps of botanists and biogeographers and the actual plant communities of Mali. In contrast to White's Table of biotic communities, Table I-3 tries to portray the actual communities. Nevertheless, it is an interesting exercise to review the ecosystems of Mali with an eye out for communities that represent historical remnants of days gone by and deserve protection as cultural natural "treasures."

The Saharan zone and its habitats have no protection in Mali. In general, there is only one area in all of the Sahara with legislated protection (Tenere, Niger). Since this is the largest protected area in Africa and includes part of the Sahel, international donors will probably focus conservation activities within Niger. The most important Saharan and, perhaps, Saharo-montane area in Mali is probably the Idrar des Iforhas (727 m). The Idrar is a southern extension of the Ahaggar massif and is responsible for a local increase in rain. It could also be considered a Sahelian locale as increased rain makes it a northern extension of this flora. It has



Areas protected by law include the Boucle De Baoule Complex which can be subdivided into the Boucle de Baoule National Park (3500 km²); Kongossambougu Faunal Reserve (920 km²); Badinko Faunal Reserve (1930 km²); Fina Faunal Reserve (1360 km²). The Elephant Faunal Reserve (also known as the Gourma Reserve) is about 12,000 km². The Giraffe Faunal Reserve (also known as the Asongo-Menaka Reserve) is 17,500 km². There are two reserves in the southwestern Sudanian zone but they have little or no administrative presence. They are the Kenie-Baoule Reserve (675 km²) and the Faya Forest Reserve (800 km²). A few smaller faunal reserves also exist. The presence of a "paper" reserve does not indicate any real enforcement of the conditions set up by the laws creating the reserve or national park. Finally, there are approximately 100 classified forests which total 6450 km² in the Sudanian zone and 710 km² in the Sahel. The Sahara has no protected areas.

TABLE 1-3: EXISTING PLANT COMMUNITIES IN MALI

1. Plantations and artificial regeneration areas

This "community" is considered permanent tree and tree-like vegetation that has a structure, but not a species mix, similar to natural stands. Species mix ranges widely from gmelina, eucalyptus, filao, cashew, cassias, acacias, mesquite, kapok, etc.

2. Natural closed or dense forested areas.

Tree, tree-like, and shrub covered areas with a crown closure of more than 50% and trees more than 5m in height. Most of the plants are deciduous in the dry season. Fire, human use near populated areas for logs, firewood, charcoal, and agriculture have dramatically altered these forests. Uncontrolled fires, set for land clearing, appear to be the major human influence. The scarcity of Parinari excelsa and African mahogany compared to "natural" forests exemplifies the vast and rampant changes that have occurred throughout the Sudanian biotic community.

3. Oper., less dense forest and wooded savanna

Dispersed trees and shrubs with crown cover less than 50%. There is an extensive ground cover of small shrubs, herbaceous and grass vegetation. Vegetation is mostly deciduous in the dry season. This community is usually a degraded form of denser forest that cannot recover from land clearing, fires and/or wood cutting. This is the most extensive area of Mali supporting grasses (Andropogon and Paspalum). In some locations, the less, dense woodland includes palms (Borassus and Raphia).

4. Gallery or Riparian Forest

Crown closure is greater than 75% and is the best preserved and tallest of the original forest types.

5. Grassland or savanna

Herbaceous and grassy vegetation with scattered trees and shrubs. The grasses are perennial to the south and annual towards the north. Change occurs when biomass drops below 1 tonne dry matter per ha. At this point, the dry matter cannot support fires and Cenchrus communities predominate. It is nearly impossible to separate out the soil-controlled grasslands that suffer natural fires from the grasslands that have resulted from human influences (clearing, fires, grazing). This area is the most important for grazers and deteriorated most during the drought.

an interesting flora, birdlife, and may have Addax, Barbary Sheep and other Sahelian/Saharan species. A thorough inventory of this area is needed.

No survey has been made of Saharan oases or ephemeral pastures (especially the Tilemsi Azzawakn valley). Most Saharan oases have been turned into date palm groves. Intact oases with representative (non-introduced) flora would be worth preserving. Protection for these isolated regions is probably impossible.

Because of the drought, hunting and grazing, West Africa has no well pro-

6. Agricultural Areas

Planted in crops annually, bi-annually or semipermanently, these lands always have vegetation associated with the cultivation/fallow cycle and are only occasionally surrounded by shrub/tree species (eg. living fences). They may be part of a grazing "system" in which the livestock move into the fields after harvesting. Agricultural lands differ if irrigated by rain, by human waterworks or flood inundation.

7. Urban Areas

The vegetation of urban or semi-urban areas poses special interest to those concerned with biodiversity. At the moment, the use of trees and other plants, especially ornamentals, is limited.

8. Water Bodies

The open bodies of water of most importance are the Niger and Senegal Rivers and the lakes associated with the Niger. Two reservoirs (Lake Bafing at Manantali and Selingue Dam) are the most important human-made water bodies.

9. Wetlands

These are seasonally inundated areas with standing water. They are important for recessional agriculture, swamp rice, shore birds, fish breeding and various disease organisms. The most important is the inner Niger delta. The seasonal marshes of the Sahel and the oases of the Sahara are also important. During the drought, the human-made wetlands for rice cultivation have been important for birds.

10. Bare lands and rock outcrops

It is important to distinguish the bare lands caused by the recent combination of human influences and drought (in the north of Mali) and the bare lands such as the bowals (laterite flats) in the south. The latter are unique habitats well represented in the Bafing area, while the bare sandy soils of the Sahel are degraded habitats.

tected Sahelian area. Mali's northern and southern Sahel have no national park. The Gourma elephant herds remain the only viable Sahelian population. The elephants plus other Sahelian species (lion, ostrich, dama gazelle) and significant inter-dunal marshes that support Sahelian birdlife raise the value of the Gourma faunal reserve to highest priority. (It was already a high priority area for IUCN's elephant committee.) The GRM needs to upgrade this partial reserve to a national park; make a serious commitment to protect large mammals; and revise the boundaries to accommodate seasonal migrations. The international community needs to make a serious long-term commitment of funds and technical aid to resolve

conflicts between pastoralists, marsh farmers and wildlife, prevent poaching and help develop tourism (Section IV.A.2).

The Asongo-Menaka faunal reserve and its flora and fauna have not been recently surveyed. It once contained the most northern population of West African giraffe but, perhaps, only three or fewer giraffes remain. The status of other Sahelian species (damas and dorcas gazelle, ostrich, topi) are not known. Asongo-Menaka requires a good inventory before a priority on its value as a Sahelian preserve can be established (Part IV). Niger, Chad, and Burkina Faso have high priority areas for international funding.

The southern Sahel and the Sudanian zone (with pockets of *Isoberlinia* woodland and Sudanian riparian) have legislated protection (Boucle de Baoule National Park) or partial protection (the whole OPNBB complex). The best protection of Sudanian undifferentiated woodland, Guinea-Congolia/Sudanian Transition Zone forest and wetland habitats is in Niokolo Koba National Park (Senegal). This park has had many difficulties with poaching, inadequate funding for guards, and the possibility of a huge dam being built in its center (4). Nevertheless, because of the presence of elephants, chimpanzees, lion, giant eland, other rare or threatened species, many riparian and special habitats, and a strong commitment by the government of Senegal, Niokolo Koba should receive international aid and technical help. There are other protected or partially protected areas of Sudanian woodland in Benin, Burkina Faso, Niger, Nigeria, Chad and Cameroon.

The Boucle de Baoule complex is, to be blunt, in competition with Niokolo Koba for international funds. OPNBB has lost more species and has more violations and difficulties with intrusions into the park than Niokolo Koba. OPNBB is connected with a series of Forest and Faunal Reserves that, with a strong financial commitment and political will, could re-introduce some of the lost species. Ideally, both parks should receive funding to preserve biodiversity. But, given the state of international funding, this appears unlikely (see Part IV).

There are no protected areas in the Sudanian Region of southwest Mali (Bafing to the Senegal border). This corner of Mali has floral ties to the Basse Casamance of Senegal. The area between Bafing River and the Senegalese border contains Sudanian woodland, Sudanian *Isoberlinia* Woodland, Sudanian riparian and possibly Sudanian Dry Forest pockets. The Bafing region is richer and less degraded than the Boucle complex (e.g., chimpanzee and giant eland populations). If a bi-national "peace park" with Senegal's Faleme Hunting Area could be arranged, this protected area would probably make the best use of international funds as it would also provide wildlife corridors to Niokolo Koba. The Bafing park is discussed under proposed projects (Part IV).

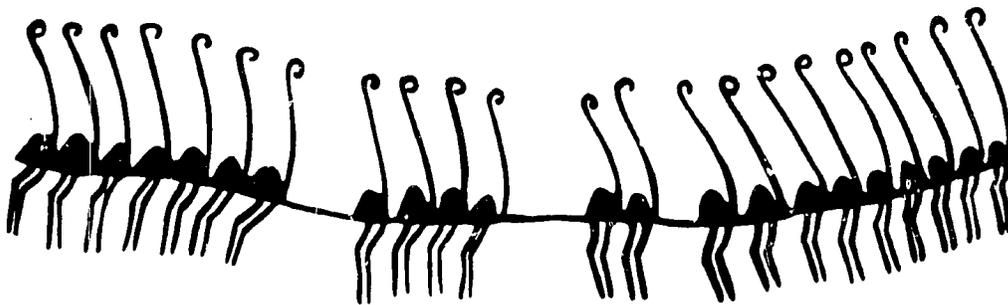
There is no national park in the south, below Sikasso, which has some of the most humid forest and intact riparian forest in Mali.

There are no protected wetlands (oases, inter-dunal marshes, lakes, floodplain sloughs, open river waters, etc.) in Mali. The highest priority area in need of protection is the inner delta. IUCN, after a survey of the delta, decided that there was no possibility of a fully protected area. Most large mammals had disappeared and the drought had placed many of the bird nesting areas in jeopardy. IUCN decided to work on conflict resolution with the goal of combining conservation with more stable economics — more assured access by local populations to natural resources such as fish, bourgu, wild food plants and wood. They have made great

progress in this direction but have run across obstacles that prevent completion of these "natural resource" agreements. An IUCN team has also begun work relating the flood pulse of the Niger to economic development. Management of the flood pulse and instream flows could help the local economies and major aquatic and wetland biota that remain (fish, birds, trees, plants, mammals). Since no fully protected areas are planned for the delta, the biological resources will be discussed under "Conservation Development and Biodiversity(Fart II).

SUMMARY

Mali can make a significant contribution to the preservation and maintenance of the planet's biodiversity. It has unique communities such as the inner delta, the Gourma, the Sudanian dry forest, and the relatively intact areas of Sudanian woodland in the southwest. The GRM has signed international and pan-African agreements that commit the government to protecting part of Africa's heritage. But, these policies have not received a high priority — in part because of the drought, in part because of the French colonial heritage, and, in part, because the GRM can see no short-term cash benefits. The international community has shown interest in fits and starts. In between, the biological resources have degraded rapidly.



C. ANIMAL SPECIES CONCERNS

C.1 Status of Knowledge of the Fauna

Mali has a rich bird and mammal fauna. Mali needs an updated overview of the status of faunal resources. Except for pest or disease-bearing species (e.g., locusts, tse-tse, simuliid flies), there has been little research on any of the insects in Mali. Some rare groups of butterflies may dwell in the south (15). There is an excellent guide to the 150 fish species in the Niger Basin of Mali and 93 fish species in the Senegal Basin of Mali (21). Mali needs an overview of amphibian species. One questionnaire survey by DNEF addresses trends in populations of reptiles (16,23). The priorities for protection of rare or threatened fish, amphibian or reptile species needs attention.

Approximately 640 bird species have been recorded in Mali, more than all the species in North America. About 15% of these birds are rare, having been seen less than six times. LeMarche (67) has written an excellent survey of bird species. There has been extensive work on the European migrant birds, the resident and breeding waterbirds, and the intra-African migrants in the inner delta (17, 20, 23, 61). However, there is a need to review of rare, unique or threatened bird species in Mali and extensively survey the southern tropical forests.

There are about seventy mid-size to large mammals in Mali (ie, excluding rodents and bats). Using a combined index of primates and ungulates, the western area of Mali has been considered by one IUCN reviewer a center Soudanian species richness with 42 species (7). For mammals, several general guides (18) and out-of-date reviews (72) are available. Besides casual and anecdotal observations, the only mammal populations recently reviewed have been elephants (71), chimpanzees (68), and large antelopes.

SCIMITAR-HORNED ORYX (*Oryx dammah*)

A truly Sahelian and semi-desert antelope, this oryx was last seen in the extreme east of Mali in the 1970s. One of the planet's most endangered antelopes, it is making small comebacks from re-introduced zoo animals in other parts of Africa and the Middle East. Extremely nomadic, they wander in search of good pastures and forage (acacia pods, succulents and some fruits). Their eating habits led to competition with Sahelian cattle herds. They disappeared from pastoralist and trophy hunting. Now extinct in Mali.



In summary, knowledge of the status of both invertebrates and vertebrates is scanty. This makes judgments of certain groups (e.g., bats, canids, otters, snakes) virtually impossible.

C.2 Status and Protection of Species

Mali's Code de Chasse formerly prohibited all hunting (56.69). Since 1986, it prohibits all hunting from the June 1 to November 30 — the season in which most animal species mate and give birth (Article 10). The Code de Chasse also limits hunting of "big game" species (Table I-4) and protects certain birds (Table I-7), mammals (Table I-5) and the Nile Crocodile from all hunting. Mali has established two partial faunal reserves: one for the last remaining herd of elephants within Mali and one for the last remaining West African giraffes in Mali (the Asongo-Menako reserve). It has one National Park in which all animals are officially protected. Eighteen to twenty animal species of planetary concern have been reported to live, at one time or another, in Mali (Table I-6).

The GRM can establish "fishing reserves" which control the kind and intensity of fishing as well as removal of aquatic mammals IUCN has an excellent project to establish such a preserve near Lake Debo. I could not discover any compilation of designated fish reserves (56).

Despite these strong laws, the actual protection of animal life in Mali is minimal. In the last decades, two species have gone extinct (the scimitar-horned oryx and the korrigum). About thirteen animal species are in jeopardy of extinction within Mali (including eight species of international concern). All large mammal populations are decidedly reduced since Jeff Sayer's survey in the 1970s (72). Two-thirds of Mali's remaining species of antelope are in jeopardy of extinction. Reptile populations are in marked decline (63) as are ostrich populations (67). The reasons for this decline will be detailed below.

The endangered and threatened species of the deserts and the northern Sahel (addax, Dorcas gazelle, Damas gazelle, slender-horned gazelle, barbary sheep) appear to have little hope except in isolated pockets free from hunting. No area is protected or scheduled for protection and the international community does not appear interested in funding recovery programs in this part of the Sahara. Two species (korrigum and scimitar-horned oryx) are already extinct and the slender-horned gazelle may be extinct.

In the mid- and southern-Sahel and the Sudanian woodlands, there are remaining populations of roan, Derby's eland, western hartebeest, Buffons kob, and

KORRIGUM (*Damaliscus lunatus korrigum*)

A member of the confusing Hartebeest group — sometimes a species, sometimes a race. The korrigum once extended from Senegal to Western Sudan. The Malian population was highly gregarious with large herds munching the floodplain grasses of the inner delta. The korrigum could also survive on dry grasses of the southern Sahel. It is purely a grazer. Last seen in the Gourma in the late 1970s. It is now extinct in Mali from competition with cattle and uncontrolled hunting.

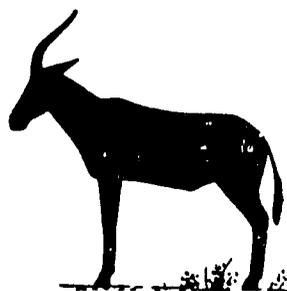


TABLE I-4: BIG GAME ANIMAL PARTIALLY PROTECTED BY MALIAN LAW (ANNEX I)*

Lion (1)	Oribi (3)
Kob (1)	Grimm's Duiker (3)
Roan (1)	Red-fronted gazelle (3)
Bohor Reedbuck (1)	Hippopotamus (1)
Bushbuck (2)	Elephant (1)

* Number in () is the number allowed to be killed each year.

TABLE I-5: MAMMALS COMPLETELY PROTECTED BY MALIAN LAW (ANNEX II)

Chimpanzee	Buffon's kob
Manatee	Dorcas gazelle
Pangolin	Korrigum
Cheetah	Dama's gazelle
Leopard	Bubal Hartebeest
African Buffalo	Derby's (Giant) Eland
Aardvaark	Aldax
Giraffe	Scimitar-horned Oryx
Barbary Sheep	Hornless female antelopes
Red-flanked duiker	Immature Hippopotamus
	Elephants with tusks less than 5 kg.

red-fronted gazelle as well as the less threatened species (bushbuck, red-flanked and grey duikers, reedbuck, oribi, leopard). Some of these species could be protected in Boucle de Baoule complex and the Gourma Faunal Reserve — if there was a strong commitment by both the GOM and the international community. But, the Boucle de Baoule complex has been devastated. The elephant, giraffe, Derby's eland and buffalo have disappeared. The roan, hippo, western hartebeest and waterbuck as well as many smaller species are all threatened (see Part IV for proposed project). Re-introduction of the Derby's eland and African Buffalo are possible but expensive. Elephants will never be re-introduced because of farming settlements within and adjacent to park boundaries.

The Gourma has no legislated protection for species other than the elephant (see "Elephant" sidebar, page 5). Nevertheless, immediate revision of faunal reserve rules and reserve boundaries could protect red-fronted gazelle, lion, ostrich, and possibly Dorcas and Damas gazelles, waterbuck and roan antelope (see Part IV and Appendix for description of project). Redefining the Gourma Faunal Reserve is a high priority of IUCN.

In the Sudanian woodlands and Sudan-Guinean zone, only the proposed Bafing National Park holds promise of protecting chimpanzees, African buffalo, and Derby's eland. Other species such as leopard, lion, roan, Kob, waterbuck, perhaps Western Hartebeest, hippo, ground hornbill, red-flanked and grey duiker, oribi, reedbuck, and bushbuck could receive sanctuary in the national park. Part IV gives details of the proposed project which is at the feasibility stage of development.

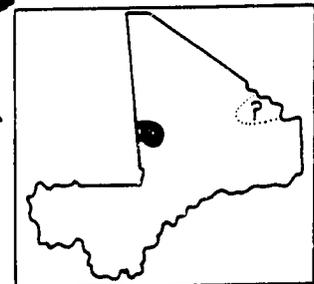
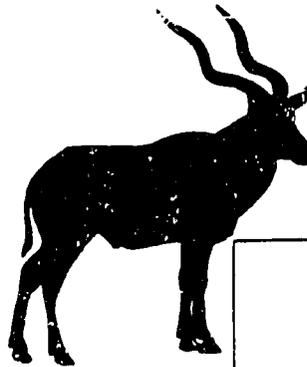
OSTRICH (*Struthio camelus*)

Once widespread from Mauritania to Chad and Nigeria, ostrich populations are now scattered, small and decreasing. In Mali, egg-hunters sell over one thousand eggs each year to mosques, to tourists for shelf decorations and as marriage presents. Ostrich skin is hunted and sold illegally into the international trade for shoe leather. Some Malian flocks have been decimated by sport hunting. Officially, the ostrich is protected by Malian law. The most viable populations are in the east and southeast and require protection in the Gourma and Asango-Menako Faunal Reserves.



ADDAX (*Addax nasomaculatus*)

Formerly throughout the entire Sahara, north to Algeria and Tunisia. Now near extinction from motorized hunting and competition with livestock. A large antelope exquisitely adapted to the desert. It moves in herds according to the irregular and patchy rains. It is believed to have a special sense to locate the rare outbursts of grass growth and ephemeral pastures. It does not need to drink water. It is not protected in any reserve in Mali. There is little prospect for protection in these remote desert areas.



SLENDER-HORNED GAZELLE (*Gazella leptoceros*)

A rare antelope of the true desert — so rare that the Code de Chasse makes no mention of it. The palest of all antelopes with the slenderest horns, the largest proportional ears for heat release and wide hooves for crossing sand dunes. If it still exists, its numbers are very low. Highly endangered, it has no protection.

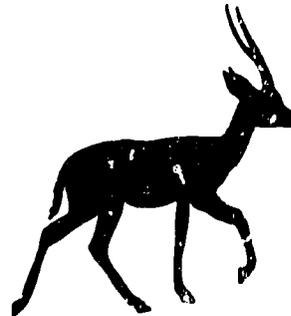


TABLE i-6: SUMMARY OF THREATENED, ENDANGERED AND EXTINCT ANIMALS
IN MALI*

Extinct in Mali:

Scimitar Oryx (E)
Korrigum

Endangered both worldwide and in Mali:

Derby's Eland (E) [E]
Leopard (T) [E]
West African Chimpanzee (sp. verus) (E) [T]
Dama's Gazelle (V) [lozonal, E]
Addax (E)

Corn Crane (K*)
Western Wattled Cuckoo-Shrike (V) ?
Yellow-Throated Olive Buibul (V)?
White-necked or Grey-necked Picathartes (V>R)? Bannerman's Weaver?
Ibadan Malimbe?
Eurasian Peregrine Falcon [E]

Vulnerable worldwide (IUCN, USFWS) and Endangered in Mali:

Dorcas Gazelle (V)
Cheetah (V) [E]
Elephant [T]
West African manatee (V) [T]
Hunting Dog (V) [E]
Slender-horned Gazelle (V) (highly endangered in Mali)
Red-fronted Gazelle (V)
Barbary Sheep or Aoudad (V)
Nile Crocodile (V) [E]
West African Dwarf Crocodile (I) [E]
African slender-snouted Crocodile (I) [E]
Pangolin [E]

Of unknown status in Mali or threatened only in Mali:

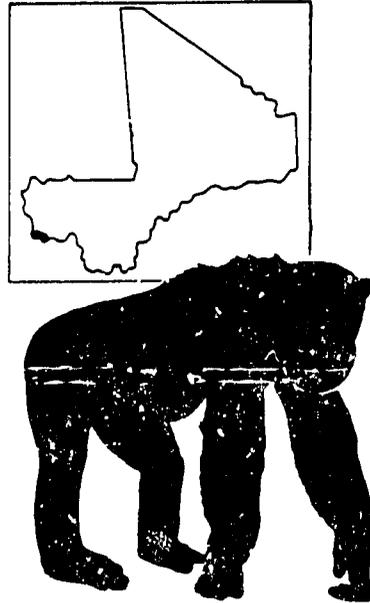
Hippopotamus (Threatened)
West African Giraffe (Endangered)
Ostrich (rapidly declining)
Spotted-neck Otter (unknown status)
Cape Clawless Otter (unknown status)
Lion (vulnerable)
Waterbuck (threatened)
Kob (threatened)
Roan (vulnerable)
Western Hartebeest (vulnerable)
Red-fronted Gazelle (threatened)

* IUCN Categories are in (). E (endangered); V (vulnerable); R (rare); I (indeterminate); K (insufficiently known); T (threatened); CT (commercially threatened).

USFWS Categories are in []. E [endangered]; T [threatened]; V [vulnerable].

WEST AFRICAN CHIMPANZEE (*Pan Troglodytes versa*)

Chimpanzees are the highest priority category of primates for conservation. The threat to their existence and their taxonomic uniqueness give them a special place among endangered animals of the planet. Mali has the northernmost population in the world — a dryland population of special interest to those anthropologists who believe that humans evolved from the forest by adapting to savanna conditions. It also has the westernmost population of the "Casamance region" — an area of special primate biodiversity. There are probably no more than 1000 chimps in Mali. They have no protected area, are hunted near the Guinean border, and lost some crucial habitat when the Manantali dam flooded the riparian forests of the Bafing. Their location, movements, ecology and protection are of highest priority. The proposed Bafing National Park should try to accommodate a large part of the remaining population.



In the wetlands, manatees, hippos, waterbuck and Buffon's kob have been greatly reduced by dam construction (Selingue and Manantali), the drought, hunting, and displacement by human activities such as floodplain grazing. The Malian populations of manatee, Buffon's kob, the hippo, Cape clawless otter and spotted-neck otter populations need to be surveyed. No population is known within a protected area.

Finally, the hunting dog and cheetah may be extinct in Mali. They are disappearing rapidly throughout most of West Africa. The ostrich needs much more protection as thousands of eggs have been harvested each year and sold commercially. The Gourma and, perhaps Asongo-Menaka, holds the best hope for these species.

Reptiles need immediate attention as both cultural prejudice and commercial takes have led to massive reductions in populations (63,64). The Nile, African dwarf and Slender-snouted crocodiles have not been surveyed in Mali.

The wetland birds of the inner delta appear more influenced by water levels in the river than hunting. Since the drought, nesting groves of *Acacia kirkii* trees have been reduced by two-thirds. Human consumption of young egrets and other nestlings is common. IUCN and DNEF support an excellent project which has written common property access and use agreements to protect some of the remaining groves. Recent obstacles include compliance by outsiders who feel free from local laws and conflicts between administrative units (88). The population and distribution of other birds of concern are not known.

In summary, little is known about many groups of mammals, birds, reptiles, fish and invertebrates in Mali. The biological diversity of wetland birds is under active consideration by DNEF and IUCN. All other wildlife requires much greater attention, if Mali wishes to retain this natural resource. The causes of population

declines are discussed below, the economic importance of wildlife in Part II and possible solutions in Parts II and IV.

C.3 Causes of Population Declines

In principle, neither subsistence hunting nor commercial hunting need to reduce biological resources or biological diversity. But, over-exploitation appears to be widespread because:

— The sixteen year drought lowered diversity and populations of animal species as explained in Section I.A.

— The introduction of automatic weapons, large calibre rifles, and motorized hunting has made poaching much easier and more devastating. Illegal poachers, the army as well as the privileged, licensed hunters have been reported using advanced weapons and motorized vehicles. The majority of Malian hunters have much older weapons, little ammunition, and hunt on foot.

— Uncontrolled hunting, despite existing laws, remains the major threat to animal populations. Protection is not a high priority at the upper levels of the GRM, although many mid-level agencies (especially DNEF) appear deeply concerned. The GRM of Mali has weakened its own authority by issuing special hunting permits for protected species to ministers, foreign diplomats, emirs (Arab princes), state employees on mission, foreign and Malian construction workers and consultants, local functionaries, and other powerful personalities. For instance, according to a DNEF report, in 1987 a "cheick" (marabou) wished to eat giraffe fat to preserve his longevity. The GRM issued him a special permit to kill one of three remaining giraffes in its Asongo-Menaka Faunal Reserve -- the only remaining hope for the giraffe in Mali. The marabou himself died in 1988. In the same area, one Arab prince killed 45 Dama gazelles -- an internationally threatened and nationally endangered species.

TABLE I-7: BIRDS PROTECTED BY MALIAN LAW

Whale-Headed Stork*	All carrion-eaters:
Secretary Bird	
Saddlebill Stork (jabiru)	Marabou Stork
Bald Ibis (Waldrapp)	Nubian (lappet-faced) vulture
Cattle egrets	White-backed Vulture
All egrets (Egretta sp.)	White-backed Vulture
All storks (Ciconia sp.)	All other vultures
Hammerkop	
Spoonbills	
Flamingos	
Crowned crane	
All ibis	
Ostrich	
Ground Hornbill	
White-breasted Guinea Fowl *	

*Not reported to have been seen in Mali (67).

An influential "Bamakois" (resident of Bamako) was single-handedly responsible for the extinction of the Bougouni herd of elephants — the next to the last in Mali. The same Bamakois has been implicated in the live capture and illegal sale of chimpanzees to Senegal and Gambia as well as the destruction of ostriches between Nam-pala and Lere. None of these Bamakois have been prosecuted. Many authorized sport hunters receive permits without official payment of license fees and are not accompanied in the field by forestry agents who can monitor the species and numbers killed.

Serious commitment to species preservation by the highest levels of the GRM is a major issue. It will not be possible to convince local hunters who hunt for family food security to stop poaching until the GRM sets an impeccable example of following its own laws. In addition, potential international aid has been and will be difficult to secure unless the donors believe the GRM is serious about wildlife protection (Part IV).

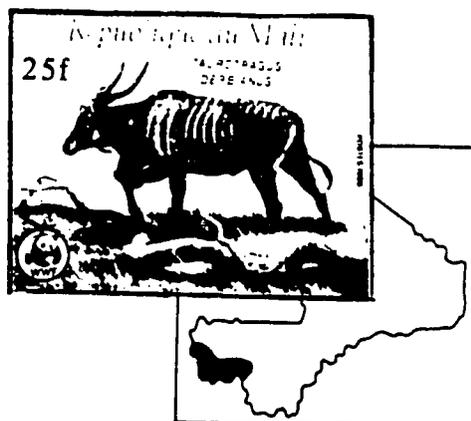
— The Code De Chasse is too general. It contains no provisions for small game to be hunted (e.g., warthogs, guinea fowl, francolin) and inadequate rulings on huntable game by region, species, age, sex or season. This has led to confusion, claims of unreasonable action by forestry agents, and inconsistencies in law enforcement. Revision of this law is a major issue in Mali.

— There are too few forestry agents to cover much of Mali. The Sahara and the area from the Bafing River to the Senegalese border have no permanent forestry agents. All areas of special concern are understaffed, under-armed, with too few vehicles and ammunition. There is no well-equipped anti-poaching team. The Asongo-Menaka Faunal Reserve, for instance, has one agent for every 83,000 ha., only one vehicle, and no ammunition. Most anti-poaching pursuits must be done on the eight available camels. In addition, in many regions, preventing brush fires and illegal firewood cutting take precedence over controlling hunting.

More important, the forestry agents receive little respect and no help from the population. Although it is difficult to corroborate stories, some forestry agents have been accused of hunting for themselves or hunting protected species for profit. To compensate for delayed payments of salary or to supplement their salaries, some

GIANT ELAND (*Tragelaphus derbianus*)

Mali and Senegal contain the last remnant populations of the largest antelope in Africa. It once extended to northern Nigeria. It is in grave danger of extinction from hunting, rinderpest and the recent drought. Extinct in the Baoule complex, a small population has been seen near the Manantali dam and other small groups may exist toward the Faleme Valley. Discovering and protecting this subspecies is urgent. In the dry season, they survive on the young leaves of Isoberlinia which also requires protection.



forestry agents have applied fines and license fees erratically, arbitrarily or punitively. (Agents receive a percentage of all fines levied.) To be blunt, in some areas visited by the author, the forestry agents are hated. Part IV will address this issue as one of the major conservation and development issues in Mali.

— Displacement of wildlife by human intrusion and competition between wildlife and livestock have greatly contributed to wildlife losses, especially in the Sahara-Sahelian borderlands. In the Sahel, expansion of livestock over the last thirty years has reduced the forage and pasture available to wildlife. The drought simply intensified overgrazing, defoliation of forage trees and competition. (In eastern Mali, the reduction of cattle during the drought may have provided a short period of relief to some gazelles.) In the southern regions (Sudanian and Sudano-Guinean zones), the expansion of agriculture has reduced wildlife habitat or forced pastoralist to use sub-optimal pasture that once fed wildlife. Further competition has occurred at waterholes, especially during severe drought years. For instance, many of the Gourma elephants died during the drought in the early 1980s (71).

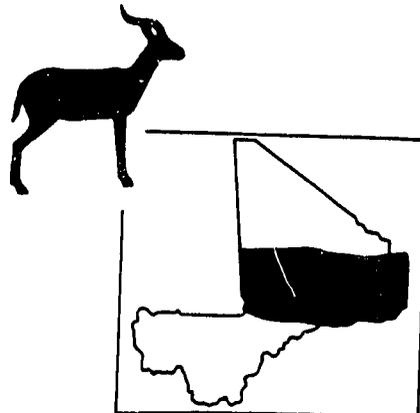
— Cross-border incursions by hunters are out of control. Mauritians hunt wildlife in the Baoule, Bafing and Farimake regions for commercial export of jerky. Citizens of Burkina Faso have been caught poaching elephants in Mali. Poachers and live-trappers from both Bamako and Guinea appear linked to an illegal trade in wildlife through Guinea to Spain and through Senegambia to other parts of Europe.

— There are no education campaigns on radio or television and no video tapes or movies that promote reasonable hunting and protection of wildlife. Since the vast majority of the population is illiterate, written material is less effective. Only WALIA, a publication for children in the Vth Region, educates the public on wildlife management and protection. The situation is of greatest importance in Bamako because the city is the center of well-equipped poachers, destructive permit procedures, commercial sale of game meat and wildlife parts, medicines, crafts, black magic potions, and the international trade in birds (see Part IV).

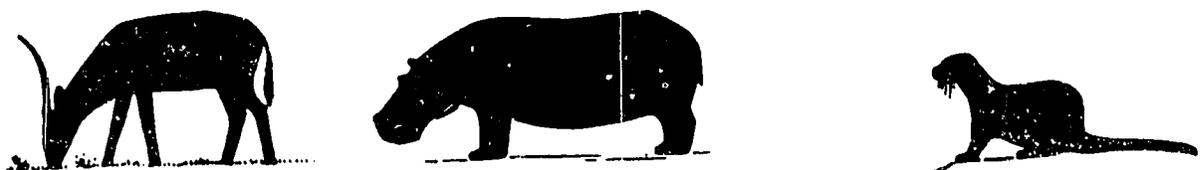
— Finally, to protect livestock from hyenas, arsenic poisoning by the Livestock Service has led to local deaths of wildlife .

DAMA GAZELLE (*Gazella dama*)

The largest of all true gazelles, the Dama inhabits the desert and outer edge of the Sahel. They once made large migrations from the Sahara to the Sahel, similar to the routes taken today by transhumant pastoralists. They mainly browse on shrubs and acacias which put them in competition with goats and camels. They require some water after long periods of drought. Once widespread across the Sahel, they are now considered endangered. Mali was regarded as one of three nations with viable populations but overhunting, the drought and goats may have pushed the dama to the brink of extinction. A few have been seen in the Gourma elephant reserve and Asongo-Menaka reserve.

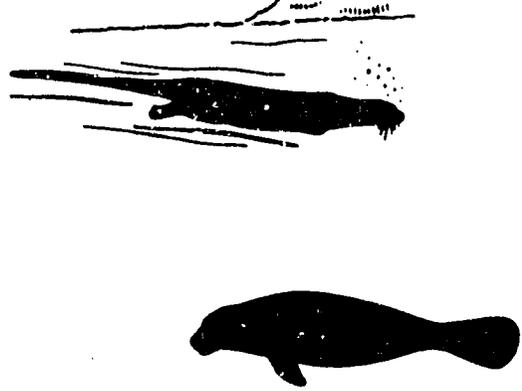


Given this rather bleak picture, this report suggests a series of projects that require both the technical and financial aid from the international community (Part IV). **Without this help -- and changes in the attitudes and policies of the GRM -- there will be no significant large mammalian wildlife of interest within five to ten years. A food supply, a source of supplemental income, a hunting heritage, and natural treasures that are part of the cultural pride of the Mallan people will be permanently lost.**



THREATENED AQUATIC ANIMALS

The manatee, hippo, Cape clawless otter, spotted neck otter, Nile crocodile, West African dwarf crocodile, waterbuck as well as white-breasted cormorant, goliath heron, great white egret, hammerkop and many other birds all depend on Mali's rivers and lakes for their existence. Many of the mammals have been rapidly declining in Mali, from the drought and over-hunting. Some of the birds have lost protected nesting sites as their trees are over-foraged and no longer sheltered by high water. Some of these animals have never been surveyed so their status is indeterminate.



D. PLANT SPECIES CONCERNS

D.1 Status and Knowledge of the Flora

There are no more than 2,750 known species in the Sudanian zone (about 900 endemics); 1200 species in the Sahelian zone (about 40 endemics); and about 500 major species in the Saharan zone (16 endemics). Keep in mind that none of these endemics are known to be unique to Mali. There are no inventories of possible rare or threatened species in any of the three zones in Mali nor the extension of these zones that stretch across the Africa continent from Senegal to Ethiopia.

Mali needs its own written flora. Botanists interested in biological diversity must rely on more general floras for West Africa or Senegal (25,27, 28, 29, 32, 34). There are good maps of sixty-four "habitat types" (35) but specific locations of plants endemic to Mali or rare species have not been compiled. There is a need to assess threatened or endangered flora.

Mali does not have its own herbaria. Small collections can be found in Sotuba or ILCA. A more comprehensive collection sponsored by IUCN is caught in a legal battle after the death of M. Demange and may be deteriorating in the French Embassy. The arboretum in Bamako is located in a lovely location. There is a need to label plants and collect more natives for the arboretum.

D.2 Protection of Plant Species

In Mali, biological diversity focuses on maintaining populations of wild plants, semi-cultivated plants and cultivated plants. Much of the "woodland savanna" of Mali is really an "orchard" savanna in which select trees are maintained for their economic use and others allowed to die. These trees can be considered



BAOBAB (*Adansonia digitata*)

A tree that seems immortal, loved and protected by Africans. Its fresh leaves are an excellent vegetable and its dried leaves give great flavoring. The leaves are cut by herders for their flocks. The fruit makes a delicious, nutritious drink. Its roots are the source of a red dye; its bark, a useful fiber. All parts serve as medicines. The home of many birds that require hollows for their nests and staple of many monkeys and the chimpanzee. Young trees may not be replacing old trees in areas of drought, short fallow cycles or too many browsers. The Baobab should be considered for nurseries — even though seeds may take a year to germinate.

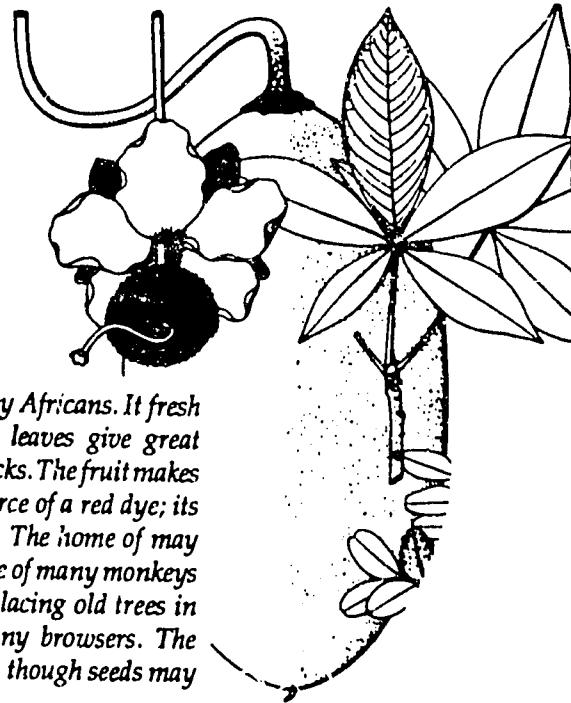


TABLE I-8: TREES PROTECTED BY THE LAWS OF MALI

No cutting of pure stands of economic interest:

Daniella oliveri*	Isoberlinia doka*
Sterculia setigera*	Cordyla pinnata*
Bambusa abyssinica	Diospyros mespiliformis
Acacia scorpoides (radiana)	Hephaene thebaica
Acacia seyal	

Completely Protected:

Butyrospermum paradoxum**	Parkia biglobosa**
Acacia albida**	Borassus aethiopicum**
Elaeis guineensis	Azizia africana
Pterocarpus arinaceus	Acacia senegal
Bombax costatum	Khaya senegalensis

*Never for firewood.

**By permit in fallow areas.

either "wild" or "semi-cultivated." Similarly, "bourgu," the most important grazing grass in aquatic meadows, can be treated as "wild" or "semi-cultivated" (pastoralists use grazing to implant roots in mud) or "cultivated" (some farmers harvest bourgu and others plant it).

In the Sahel, there is almost no tree, shrub or grass without some use. von Maydall (32) lists 114 Sahelian species of trees and shrubs used for firewood, charcoal, food (fruits, leaves, seeds, roots, exudates, etc.), construction, crafts, forage, human and veterinary medicines, windbreaks, erosion control and soil improvement on farms, shade, magic, cosmetics, dyes, tannins, gums, fibers, honey, etc. Bergeret (52) lists an additional 98 edible plants from the Sahel/Sudanian zone and shows their importance to the overall vitamin and protein nutrition of the people. Strategies Vivrières (93) gives some idea of the importance of wild and semi-cultivated plants in the inner delta of Mali, especially as drought-fallback food and income when crops fail or prices plummet. For this reason, the conservation of plant biological diversity is of utmost interest to the people of Mali and will be considered as the "gathering" economic system, parallel to hunting in Part II.

There are no rare or endemic wild grasses, vines, herbs, forbs or shrubs officially protected in Mali. Many of the "orchard savanna" and hardwood trees are protected as much by local and traditional custom as by Section III, Articles 13 and 37 of the Forestry Code (Table I-8). Regeneration and protection of these species has not been monitored since the drought.

D.3 Genetic Varieties of important "wild" plants

Mali was probably the origin of certain floating rice species. It nurtures very localized biotypes of millet and sorghum and semi-wild grains such as shibra (Pennisetum), fonio (Digitaria exilis), and water lilies (Nymphaea sp.). The genetic re-

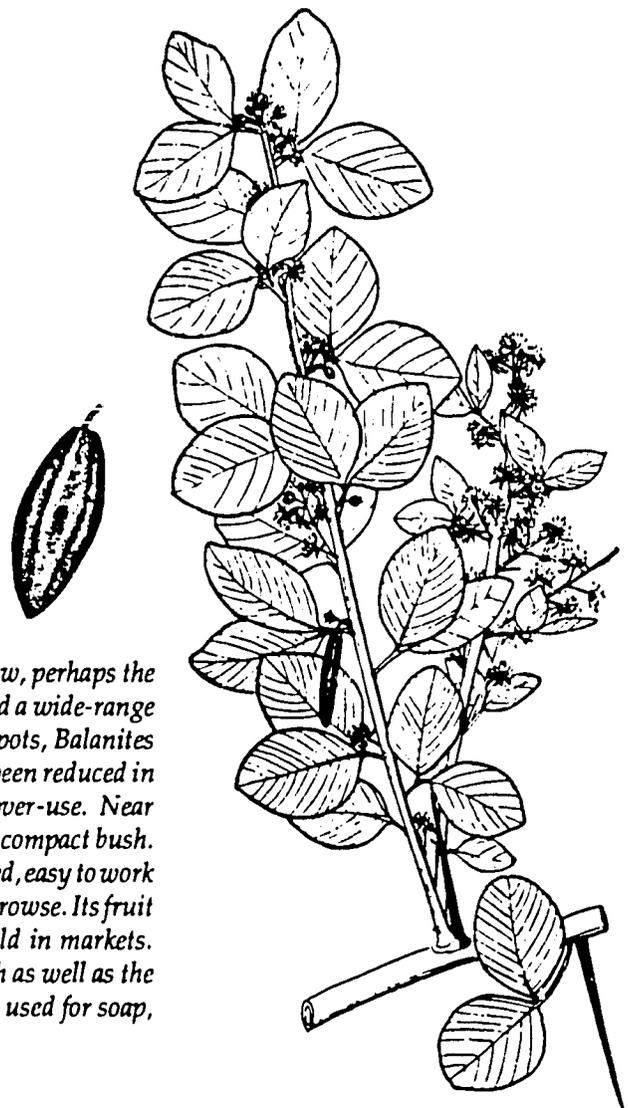
sources (the grains) have evolved special adaptations to the Sahel's rainfall irregularity (pre- and post-emergence drought and post-floral initiation drought). Despite the harsh climate, they can complete their growth and grain cycle with reasonable yields, are resistant to or tolerant of diseases, pests and parasites and have been "selected" by humans for acceptable processing, storage and consumption. These highly specific genetic resources are highlighted by the failure of 92 varieties of improved, international pearl millets tested by ICRISAT to meet the above criteria. Even pearl millets from neighboring countries (Burkina Faso, Niger) had problems (50,51). Mali's plant germplasm is an important part of both economic development and biodiversity conservation as discussed in Part II.

There is no microbiological resource center in Mali equivalent to MIRCEN in Senegal. MIRCEN produces microbial inoculum (rhizobial bacteria, mycorrhizal fungi) for agriculture and environmental restoration. Any major regeneration and restoration program like the PNLCD should have easy access to microbial resources.



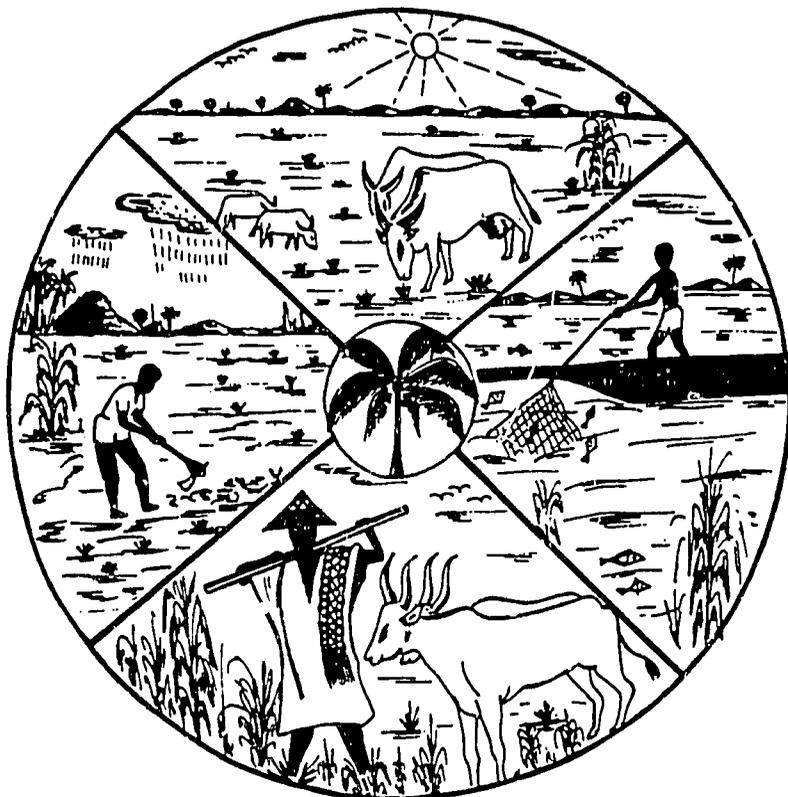
BALANITES AEGYPTICA

A native tree of the Sahel praised as equal to a milk cow, perhaps the highest praise in an arid land. Grows in many soils and a wide-range of rainfall with excellent (60%) germination rates in pots, Balanites would be a welcome addition to local nurseries. It has been reduced in areas of extreme drought and by over-browsing and over-use. Near villages it is so exploited that this tree remains a small, compact bush. Excellent firewood and charcoal. Its wood is fine-grained, easy to work and insect resistant. Livestock and camels prefer it for browse. Its fruit (the "desert date") is eaten like candy and widely sold in markets. Strong emulsions of the fruit can be used to poison fish as well as the bilharzia snail. Nuts used by children in games; oil is used for soap, etc. etc.



**PART II: BIOLOGICAL DIVERSITY AND CONSERVATION
DEVELOPMENT**

STRATEGIES VIVRIERES



**RAPPORT SAISONNIER DU SUIVI
ALIMENTAIRE DELTA SENO**



UICN



S.C.F



OXFAM

Strategies Vivrieres (93) is a publication that monitors nutrition in the delta region. It is the best analysis of how households handle changes in production as they change with rainfall, riverflow, prices and the need for manual labor. The publication has detailed recommendations on the importance of drought-fallback wild plants and the increased food security for each of the delta's five main production systems. It is co-sponsored by IUCN, SCF and OXFAM.

Part I focused on preservation of biodiversity in national parks and faunal reserves. This section focuses on activities to combine household food security, production of food and income generation, economic development with the conservation of biological diversity. Hunting, gathering wild plants for food and crafts, tourism, pest control, fire management, forestry, grazing, fishing and agriculture all impact biological resources and biological diversity. This subject is very new. Only general papers on economic development and natural resource management (soils, water, vegetation cover) have been written (1,14, 109, 110,112). Analyses combining both species and production systems have not been done for any country. The results are exploratory.

A. ANIMAL RESOURCES

A.1 CONSUMPTIVE USES OF ANIMAL WILDLIFE

In Mali, the maintenance of animal biodiversity must seriously consider subsistence hunting for food, especially as a drought-fallback food staple. Between 25 and 40 species are considered bushmeat. Their consumption usually occurs within 10 km of the village. Consumption increases with the availability of advanced firearms. Local enforcement of hunting regulations may reduce subsistence hunting. Cultural preferences (eg, muslims do not eat monkey meat or chimpanzees) can reduce pressure on individual species.

Between 1972 and 1974, the FAO reported that 65% of the protein supply of the rural population of Mali came from game. Even if this estimate is inflated by poor sampling, there are areas of Mali like Wassalou where almost 90% of the men hunt and 94% use part of their take for home consumption and part for extra cash. In general, subsistence hunting does not hurt rare species. Subsistence hunters eat small, easily transportable and relatively fast-growing species such as francolin, guinea fowl, warthog, rabbit, porcupine, Grimm's duiker and patas. But, there are significant exceptions. Increasingly rare species such as hippopotamus, kob and roan antelope are also prized, edible meat. In Mali, biodiversity projects and regulations must consider these traditional hunting cultures who have suffered greatly from the drought. They have not quite caught up with the new reality in which over-hunting prevents the regeneration of populations. Sympathy and education through hunters associations are minimal needs.

Sport hunting is not widespread among rural Malians in part because ammunition is limited. Less than 5% of all Malian hunters interviewed had any interest in sport hunting. Sport and trophy hunters who have political influence, automatic weapons and motorized vehicles have been the most destructive to biological diversity because these hunters prefer the "glamorous" rare and endangered species.

Commercial hunting for sale ("mercantile poaching") has been a major consumptive use of wildlife because it is uncontrolled (see below). Commercial meat sales have significantly reduced hippo, roan antelope, Buffon's kob, bushbuck and warthog populations. The sale of animal parts for trophies, ivory, feathers, eggs, and leathercraft singles out large mammals such as lions, hippos, or elephants; birds such as the ostrich; and reptiles such as python and crocodiles. All these populations are in rapid decline.

The people of Mali employ an extensive pharmacopeia based on wild animal formulas. In addition, animal parts possess for both West Africans and Euro-Americans many "magical" properties. In Bamako, 60% of the citizens have, at one time,

been treated with products derived from hunting or wildlife. A typical market will sell pangolin paws (to prevent rain), hyena skin (to cause discord), python meat (to induce abortion), snake and crocodile handbags and belts (to give tourists "attractive powers" and an opportunity to display wealth) and stuffed birds and turtles (a Euro-American fetish/trophy). In Sikasso, the market sold chimpanzee hands and antelope horns. These West African and Euro-American cultural habits are hard to change, especially when they contribute to the cash economy of healers and artisans.

Finally, an unknown number of wild animals, particularly chimpanzees, are live-trapped for medical export or the illegal trade in endangered species. The legal trade in birds may export more than 30,000/year. The species involved are not known but may include the Yellow Canary and the Senegalese long-tailed parakeet (two major export species in Senegal).

Since hunting is so widespread and endemic to Mali, the best hope for conservation is to give some legal responsibilities to the hunters in exchange for revised hunting codes (Part III). Subsistence hunting of small game can be encouraged, while commercial or market hunting more tightly regulated with transport taxes and marketplace surveys. Sport hunting of rare or glamorous species simply increases bitterness between the wealthy who have access to special permits, weapons and motorized vehicles vs. the poor who must secretly hunt to avoid the forestry agents. Sport hunting contributes little to food security or the national wealth. The "multiplier effect" of wildlife tourism has been shown to have much more beneficial impacts of employment, wages, and economic returns (1). The illegal export of endangered wildlife requires the GRM to sign the CITES III agreement and the organization of an anti-poaching team for the nation (Part III).

A.2 PEST CONTROL AND ANIMAL BIODIVERSITY

The goal of animal pest control and biodiversity is to manage the pest without harming other species, including humans (4). In Mali, pest management has focussed on five areas:

- waterbirds which consume rice and wild grasses (Table II-2);
- terrestrial granivorous birds that consume rice, millet, sorghum and maize (Table II-3);
- large and mid-sized mammals such as baboons who raid crops or lions that kill livestock;
- small mammals, especially rodents, that attack tree seedlings, grain and vegetable crops; steal from granaries and households; damage irrigation earthworks by burrowing; chew plastic irrigation pipes; compete with domestic livestock for grass and browse; and carry human diseases (Table II-4);
- invertebrates such as migratory locusts and grasshoppers; crop pests; malaria mosquitos; simuliid flies which transmit onchocerciasis; snails that spread schistosomiasis; and tse-tse flies.

The central agency concerned with pest control is the Service Nationale des Protections des Vegetaux (Crop Protection Service, CPS) under the direction of M. Sountera. The CPS is sensitive to the potential negative impacts of pest control measures.

The main waterbird pests of rice have been quelea, garganey (a duck)

TABLE II-1: ORGANIZATIONS INVOLVED WITH WATERBIRD BIODIVERSITY

ORSTOM
OCLALAV
Operation Riz Mopti (ORM)
Eaux et Forets
CRBPO (Centre de Recherches sur la Biologie des Populations d'Oiseaux)
OMVS
FAO
Office du Niger, Canal du Sahel
RAMSAR
IUCN
Musee de l'Histoire Naturel, Paris

and godwits (a shorebird). In contrast to Senegal, rice losses have been erratic and localized. Garganey and godwit have been a concern to the international community. They are an international species migrating from Europe to Africa each year. The Bozo people capture garganey by spreading cinders to mimic a water surface and netting them for sale. There is no evidence that this species-specific hunting has caused any major losses. The drought appears to have more influence. Mali has had no need for chemical controls of bird pests for about ten years. Possible impacts during migration (hunting in Europe, toxins, nesting grounds) need further study.

Quelea and the golden sparrow have been chronic granivorous bird pests in Mali, especially around irrigated agriculture. In normal rainfall years, marshes are sufficiently widespread to disperse quelea and golden sparrows and reduce pressure on crops. In normal rainfall years, only about 100 ha are aerially sprayed with Fenthion (at 100g/liter and 3 liters/ha). The spraying usually covers a 10 to 20 ha roosting area with a maximum area of 100 ha. The spraying occurs during September at nest sites, and October through December at roosting areas. The relatively dry weather limits the spreading of Fenthion. In the last fifteen years, drought years have favored the golden sparrow. Large concentrations of these birds have led to spraying of 1,000 to 900,000 ha a year. The use of Fenthion is limited but obviously has impacts on non-target species. Tree destruction, a very harmful approach to pest control, is not used to control nesting and roosting sites in Mali.

The Senegalese long-tailed parakeet is Mali's major millet pest (besides insects), particularly in the Bamako area. But, severe depredation occurs only occasionally. CPS does not rely on chemical controls. Scarecrow techniques suffice. In fact, bird resistant millet varieties with long awns were not seen in Mali. The Senegalese parakeet is a major component of the exotic bird export trade. Thousands have been captured and sold to overseas markets. The export demand is indirectly acting as a beneficial pest control technique. The export trade is relatively harmless to other species and profitable to Malian traders.

TABLE II-2: WATERBIRD "PEST" SPECIES AND THEIR FAVORED FOODS

Ruff	Lodged rice with invertebrates
Black-tailed Godwit	Cultivated rice > wild rice, tubers, other seeds
Fulvous Tree Duck	Cultivated rice > Wild grass > wild rice > water lily
White-faced Tree Duck	Tubers > rice > water lily > wild grass
Garganey	Wild grass & water lily > all other seeds
Egyptian Goose	
Knob-billed Goose	Prunes young rice. Causes mire and sprout death.
Glossy Ibis	Immature rice

The large and medium size carnivores (lions, leopard, spotted hyena, hunting dogs) are no longer a widespread problem in Mali. If anything, the populations of all carnivores, except hyena and jackals, are threatened with extinction. Use of strychnine to control hyenas hunting livestock has occurred in the Gourma area. Many non-target species died. Selective hunting is the preferred method of pest control. It kills only the pest. There is a need for closer coordination between livestock services who spread the strychnine and forestry agents in Mali. Given Mali's low populations of wildlife, non-target poisoning is no longer a viable option.

The vegetarian mammals (baboons, warthogs, vervets, rats and, to a lesser extent, hippos and elephants) far surpass carnivores in causing economic losses. Baboons and warthogs are shot when they raid farms. Although hippos can devastate rice fields and elephants can devastate field crops, these species are so rare that hunting should be prohibited. There is a need throughout West Africa for a review of non-harmful pest control for large mammals (solar powered electric fences, labor intensive vigils, rotational "scarecrows" such as rattles, dogs, shooting blanks, human voice recordings).

Rodent outbreaks occur erratically in Mali. The loss of predators such as pythons, increased disturbed habitat, and the drought have led to more frequent outbreaks. Biological control methods (sterilants, parasites, predators, introduction of deleterious genes) have either not been investigated for individual species or proven ineffective. Mali has tried Chlorofacinon (an anti-coagulant bait) but found application rates were

TABLE II-3: TERRESTRIAL GRANIVORE BIRDS CONSIDERED PEST SPECIES BY FARMERS

Village Weaver (*Ploceus cuculatus*)
 Long-tailed Parrots (*Psittacula krameri*)
 Black-faced Dioch (*Quelea quelea*)
 Red-headed Dioch (*Quelea erythropis*)
 Yellow-crowned Bishop (*Euplectes afer*)
 Black-headed Weaver (*Ploceus capitalis*)
 Buffalo Weaver (*Bulbalornis albirostris*)
 Blue-eared Glossy Starling (*Lamprocolius chalybaeus*)
 Golden Canary

The CPS has set as a high priority on the destruction of 50,000 liters of dieldrin left by OCLALAV and, perhaps, the unused portion of Lindane from France. CPS would also like to have its own laboratory to analyse residues and assess pesticide formulation and quality. Training in ULV application and aerial spraying, as well as research and training on secondary ecological and health impacts, would benefit the protection of biological diversity in Mali. There is no total accounting of pesticide and herbicide use by region, though cumulative and multiple impacts will be localized. (See proposed projects, Part IV.)

The amounts and locations of pesticide use involved in malaria, onchocerciasis, and tsetse fly control (see sidebars) could have important impacts on other species. WHO has been conducting extensive work on chemical and bacterial pesticides for control of simuliid flies (the carrier of onchocerciasis) and, more recently, on a vaccine. The tests have eliminated those pesticides with long-term harmful impacts on fish and other aquatic organisms (96,97,98,101,102). There is a need (beyond the scope of this report) to coordinate and account for all pesticide use in Mali.

The elimination of simuliid flies have opened up tracts of riparian forest to settlement. This new settlement will have consequences to tropical forest protection and the inhabitants, especially birds, within the forest. These areas were not visited by the author because of time and financial limitations.

US AID has taken a keen interest in the control and impacts of pesticides. In 1978, US AID underwrote the Integrated Pest Management program which terminated in 1985 without producing any technical IPM packages. In 1984, when Mali had no pesticide regulation, US AID successfully persuaded CPS to use only-EPA tested and approved pesticides. In 1985, US AID sponsored a mission to investigate dieldrin residues. The team reported that impacts were weak and of no concern. In 1987, it paid DYNAMAC corporation to investigate the secondary impacts of pesticides used against locusts. DYNAMAC's work (99,100) was poor and ultimately produced no verifiable results but the effort focused attention on the problem of pesticide residues and the need for a lab in Mali to perform residue tests. In 1988, US AID helped Mali handle an ill-planned importation of Nosema (a protozoan biological control for locusts). US AID's influence and the quality of CPS work have greatly mitigated any negative impacts of herbicide and pesticide uses on biological diversity.

LOCUSTS AND BIODIVERSITY

The map shows an outbreak of locusts that began in Mali's inner delta and spread throughout southern Africa. Locust control can be a major cause of human starvation and loss of income-generating production. Locusts are cannibals and can reduce their own numbers under the right conditions. In addition, the preservation and maintenance of other species can help control locusts. During the egg stage, a parasitic wasp reduces hatches. In the hopper and adult stage, parasitic flesh flies reduce populations. Adult predators include ants and, locally, lizards, snakes, white storks, eagles, Abdim's stork and marabous. Ant lions, certain wasps, kites, European storks, greater bustards and mammals are less important. Protozoa will play an important part in integrated pest management. Keeping this foodweb in mind is a major goal of locust and biodiversity management.



TSE-TSE, TRYPANOSOMES AND BIODIVERSITY

Besides clearing land for food production, clearing woodlands to control disease has been the major cause of habitat destruction. Tse-tse flies carry trypanosomes which cause sleeping sickness in humans and "nagana" in cattle. Like cattle, many wild species are infected by trypanosomes. Both zebu cattle and wildlife suffer little unless under other stress (drought, starvation). In the colonial past, it was believed that wildlife transmitted nagana and sleeping sickness by way of the fly. Hundreds of ungulates were killed to prevent the spread of nagana and sleeping sickness. It is now known that this method of transmission is rare. Most wildlife trypanosomes do not affect humans. The colonial theory of the "animal-fly-man" route is exceptional. It was used as an excuse to replace wildlife herds with cattle.



From the biodiversity point of view, neither clearing woodlands nor sprayed insecticides are the best strategies to control tse-tse flies. Sprayed insecticides have provided only temporary relief with harmful foodchain impacts. Invasions of cattle into cleared and/or "sanitized" areas have led to soil erosion, impoverished soil and over-grazing. New techniques using screens impregnated with "ox perfumes" (an attractant) plus insecticide can bring tse-tse under control with much less damage. This technique AND maintaining the thick grass/woodland as a source of game (protein) for local villagers does the least damage to biodiversity. It provides the best sustainable economy for local villagers. The destruction of Sudanian woodlands creates only short-term, non-sustainable, food and income increases (103).

A.3 Non-consumptive Uses of Wildlife

Non-consumptive uses of animal life include photography, zoos, birdwatching, wildlife tourism, scientific research, game ranching, etc. Very little information is available on the number of tourists who visit Mali, in part, to see wildlife. No summary of the amount of money spent on research related to biological resources is available. There is no game ranching or farming, bird breeding, crocodile, or snake or fish farming.

Mali has a great potential for the combination of wildlife and cultural tourism. For instance, a tour that included a boat trip through the inner delta (birds), Gourma (elephants and gazelles), the Dongon (dances and architecture), Timbuctou (history), and Mopti (history and handicrafts) would be very popular. Mali has not yet developed the infrastructure or given this kind of "package" tourism a high priority. Other projects in which biological diversity could play an important economic role (Boucle de Baoule National Park, Bafing Proposed National Park) will be addressed in Part IV.

The zoo in Mali has about 50,000 visits per year. The zoo has had financial problems and needs more local species to be truly educational as well as entertaining. The zoo offers one unique non-consumptive money maker. The Zoo sells lion urine as a wide-ranging curative at US \$5/liter. If the lion produces 3.5 liters/day, the yearly income exceeds \$6,000 US. This is nearly equal to all receipts from entrance fees in 1986.

B. PLANT RESOURCES

B.1 Wild Food and Craft Plants and Biodiversity

Wild plants in Mali are an integral part of nutritional survival strategies for 90% of the population. They provide crucial fall-back foods plants during drought-years (Panicum laetum, water lilies, fonio, gigitte, wild rice, palm wine, honey). In good years, wild plant harvests supplement income through trade and sales in local markets. For instance, Acacia nilotica pods can be easily transported and sold for tanning. Other acacia pods are traded as livestock feed. Pterocarpus lucens leaves are sold as supplemental forage. Wild plants enter the crafts trade (e.g., palm mats, baskets, thatch) and commercial markets. "Wild" plants contribute to the health of the population which relies extensively on botanicals.

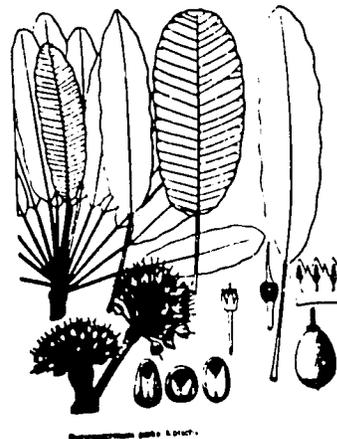
Any practical concept of self-sufficiency in Mali will ultimately include the wild plants. For many families, food security is impossible without access to and use of these plants. Sedentary agriculturalists with reduced access to wild plants (compared, for instance, to transhumant fishermen) always suffer most during times of crop failure (93). Food security in Mali requires a family to flexibly exploit multiple production systems, including secure access to wild foods.

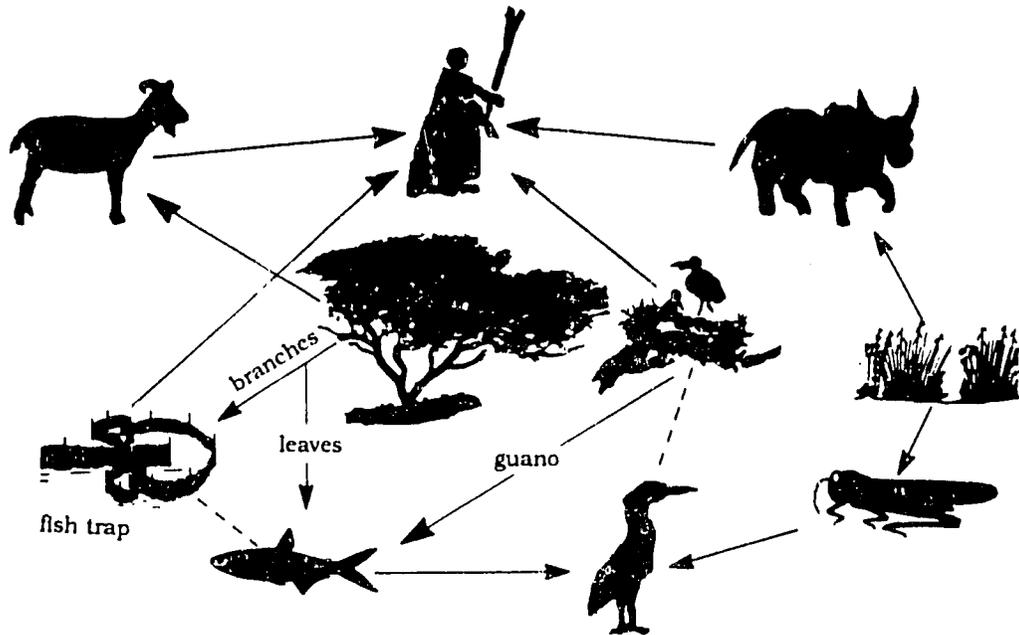
Wild and semi-cultivated plants connect with biological diversity in five major ways: (1) The wild gene pool requires protection as the plants may contribute genes to improve varieties of cultivated crops (e.g., rice); (2) The wild or semi-wild gene pool requires protection as a resource for plant breeding and selection of the quasi-commercial plant products (e.g., karite, Acacia senegal); (3) With some selective breeding, the wild varieties maybe able to produce more in situ (e.g., bourgu or water lilies) greatly increasing food security and supplemental cash incomes; (4) Many of the medicinal plants may have useful properties; (5) Some of these plants play an important role in the foodwebs and support other useful species (e.g., Acacia kirkii).

Until recently, all these "wild" species had been considered by Malians as gifts of God or nature. In their lifetimes, farmers, pastoralists or fishermen never dreamed of planting natives. But, in order to restore the much wanted biological diversity, it is necessary for both Malians and international donor groups to overcome this mental barrier. A few women groups have begun cultivating native plant species in their own special gardens. There is a need for more extension work and technical agents to promote cultivation or care for wild plants. There is a need for research on the requirements of water lilies, various forms of wild rice or Panicum

SHEA NUT TREE (KARITE), *B. parkii*

Before plastics and the expansion of the Asiatic kapok plantations, Mali kapok exports averaged between 1 and 3% of total exports. Until the drought which spurred gum arabic synthetics, Acacia senegal harvests contributed significant cash income to nomadic peoples. Until recent financial difficulties in state-owned factories, shea butter and almonds from the karite were a major export from gathering nuts from "wild" orchards. At the moment, doum and ronier palm remain the only "wild" plant export item and the ronier palm heart commerce has diminished from over-harvesting.





Acacia kirkii not only supplies browse to goats, branches for fish traps, and bird nestlings for supplemental food, it also provides the main nesting area for cattle egrets. These birds feed in fields and can dampen the severity of locust attacks on cultivated plants and pasture. The presence of many nesting waterbirds fertilizes the waters beneath *Acacia kirkii* with guano which, in turn, increases fish production. Local people say: lots of birds means good fishing. It is these biodiversity linkages that need greater publicity.

laetum. The few collections of wild seed varieties have not been brought back into projects to increase food self-sufficiency. Among farmers, the ideal variety is an attractive, high-yielding, drought-resistant, multipurpose plant. The conservation of wild plants is another aspect of the adage: good conservation and good economics can go hand-in-hand.

Biological diversity can be maintained through a number of activities: by collecting the genetic resource as seed or tissue culture and storing them in genetic resource banks; protecting plants in place (e.g., special reserves or national parks); spreading of varieties and species by growing them in nurseries and distributing them to farmers or pastoralists (49).

Mali does not have its own seed bank or tissue bank. In 1980, ICRISAT began to collect Malian cereals (sorghum and millet). In 1985, IBPGR made the first collections of "wild" foods in cooperation with IER. IUCN gave support. Since then, wild and weedy rice, local cereals (shibra) and forage species have been collected. ORSTOM, USDA and ICRISAT have Pennisetum collections. ILCA has forage collections. IRRI has rice collections. DANIDA has some collections of woody plants. *Acacia senegal* has been widely collected and trial plantings are in process. *A. senegal* has many values but the GRM is most interested in its cash value for gum arabic. US AID has a project (\$15-18,000 US) for DNEF (Mopti) to collect locally for a seed bank and nursery trials. It is hoped to involve the Peace Corps (PL-480 funding) with training in Burkina Faso.

B.2 Range, Browse, Silvopastoralists and Biodiversity

Grazing, browsing, livestock and biodiversity in Mali have many facets. Foremost, the Sahel is a domestic livestock resource. The goal of conservation development will not be to re-create pristine Sahelian steppes and shrub grassland. The goal will be to maximize livestock off-take and milk production and, at the same time, keep the Sahel from degrading into a "desert-like" landscape or into sterile soil. The question is: does thinking about biological diversity play a role in maintaining Sahelian long-term livestock production?

The silvopastoral system in the Sahel is based on grass, trees and shrubs (29, 41, 42, 43, 44). Because browsed trees never grow tall, there is some confusion between trees and shrubs. The agro-foresters, with some justification, say "trubs." Trubs represent an overall 10-20% of the annual stock diet in terms of dry-matter uptake but much more, in terms of protein, carotene, phosphate and minerals. They are the major source of nutrition in areas of Mali with a long dry season. Livestock cannot survive without them. Ideally, browse should represent 30% of dry season intake and 5% of rainy season intake. From the biodiversity point of view, the essential inclusion of "trubs" in Sahelian restoration and "anti-desertification" programs has only recently been accepted. Optimally, the Sahel can support 100 to 400 trubs per hectare dotting a herbaceous layer of annuals and herbs. There are about 100 native Sahelian species. About 100 more from East Africa might be appropriate as nursery introductions.

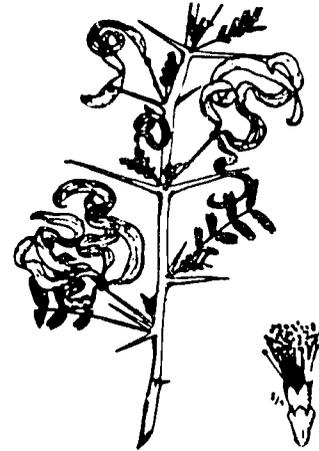
The major families in the Sahel are the Capparidaceae and Mimosoideae. The Caper family species are crucial because five of the seven trubs with permanent or quasi-permanent green leaves belong to this family. They are also the most protein-rich browse available to livestock. Regeneration of Sahelian silvo-pastoral environments has greatly underemphasized the importance of the Capparidaceae.

Right before the rains, at the driest time of year, Commiphora africana leaf out "prematurely" and supplies almost all the protein available to pregnant cows. Other species set leaves after the first rains (e.g., Combretum aculeatum). They are browsed throughout the rains and into the early dry season. Trubs that grow out of termite mounds remain green longer into the dry season — an important aspect of silvopastoral biodiversity. Finally, some trubs blossom in winter (e.g., Combretum Terminalia) and provide browse as grasses die out. This sketch outlines the need for any livestock program to take into account the species depletion that has occurred from drought and over-harvesting of trubs for other uses (usually firewood). Sahelian regeneration and livestock production require nurseries and plantings that in-fill the sequential seasonal gaps (the phenology) in browse species in order to increase production and provide a long-term sustainable silvopastoral production system. This has not been mentioned or taken into account in livestock management programs in Mali.

In the Sudanian zone, the Mimoso and Caper families are replaced by legumes (mostly Caesalpinias and Papilionias). In addition, there are many tall perennial grasses (Andropogon and Hyparrhenia). These must be burned for access by livestock to the protein-rich regrowth (see below) and to reduce tse-tse flies. Grossly put, the question for biodiversity in the Sudanian region is should silvopastoralists use trypanotolerant species (Ndama breeds) and save the woody layer or burn the woody layer and graze Zebu breeds which are more susceptible to tse-tse trypanosomes? A sustainable silvopastoral system and biodiversity can be maintained with early dry-season burning (to save the "trubs"), a three-year rotational burn and

SILVOPASTORAL TREES

Trees, especially *Acacia raddiana*, have rightly received attention as crucial members of the northern and southern Sahel silvopastoral system. But, they must grow into trees and not remain shrubs. As trees, their branches shield the soil, reduce evapotranspiration, reduce temperature extremes, create a scaffold for vines that further increase shade, add organic matter and life-support to microbes in the soil beneath the canopy, and create some of the best pockets of pasture. In addition, the reduced temperatures slow down mineralization of organic material but enhance the mobilization of nitrogen. The roots get to trace elements and recycle them through the leaves. The shade reduces water requirements of livestock. From the herders point of view, tree foliage is crucial to his livestock. *Acacia* leaves have three times more protein than grass for equal dry weight.

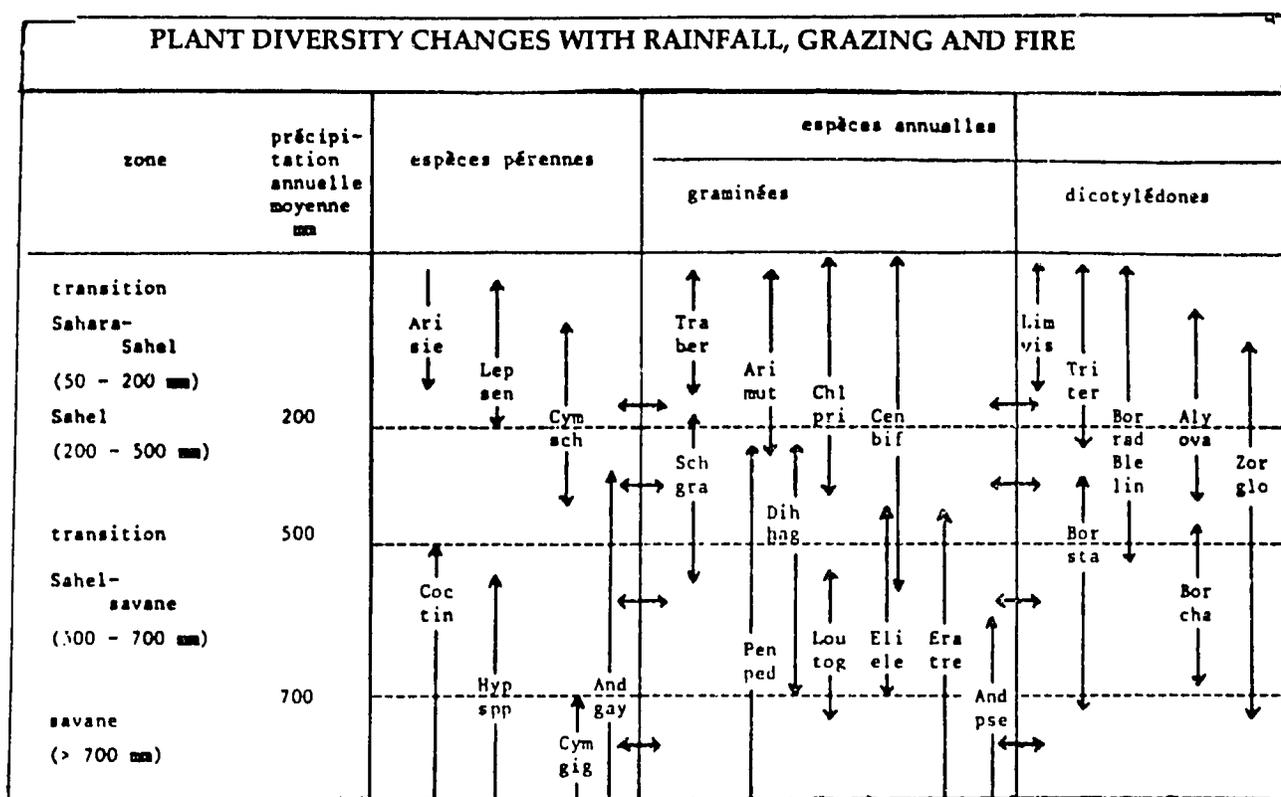


trypanotolerant species as suggested by Hiernaux (40b, 43). It should be considered in the revision of the Code de Feu (Part III).

Finally, in more sedentary and more goat-dominated systems, trubs are lopped and fed to penned or staked household animals. *Pterocarpus lucens* and *Acacia albida* are the two most important species in Mali. *P. lucens* is such a good browse species (if not the best in the Sahel) that its leaves are sold in markets. Both have suffered greatly during the last sixteen years from low rainfall and firewood cutting. If *P. lucens* is converted from browse to firewood equivalents, a town of 15,000 consumes the equivalent of 37,000 hectares of *P. lucens* browse as firewood each year! Yet, *P. lucens* is not part of the reforestation programs in Mali.

Because deep-rooted trees suck up rain that percolates below the grass root zone, their disappearance is also symptomatic of the Sahel's inability to employ a large part of the rainfall it receives. Tree disappearance points down an irreversible road to desertification. **The restoration of a species mix that is more in balance with the rainfall regime will, at the same time, restore higher quality pasture and a year-round food supply to livestock. Biodiversity and economic development, again, run parallel.**

The annual grasses of the Sahelian zone are believed to be a fire disclimax. Perennials have survived in the driest areas because the biomass is too low to carry fire. Conversely, in the wettest areas in the south (Sudano Sahelian zone), the perennials survive because of the moist soil conditions and larger root systems. Fire, over-grazing and drought can switch perennial grassland to annuals in a few years time. But, the restoration from annual to perennial grasses is slow. Rainfall, local soils, and dry season vs. rainy season stocking rates alter the species composition of the range between perennials, annuals and dicotyledons (see sidebar). In addition, other species (termites, ants, locusts, birds, rodents) prey on particular species and disperse favored seeds. While livestock may graze away 30% (rarely 50%) of the above-ground grass biomass, these non-domestic species also reduce above-ground plant mass by an additional 30% to 50%. Their influence on species composition is not well-known.



This chart (48) shows how species composition of rangeland communities changes with fire, rainfall, and grazing. Vertical arrows indicate the distribution of each species with rainfall. Northern movement occurs under the influence of consecutive high rainfall years. Southern movement with consecutive years of drought. Horizontal arrows pointing to the right occur with repeated fires and/or overgrazing. Changes may be abrupt (perennials to annuals in drought) or slow (perennials to annuals with overgrazing).

Abbreviations: *Alysicarpus ovalifolius*; *Andropogon gayanus*; *Aristida mutabilis* and *sieberiana*; *Blepharis linariifolia*; *Borreria radiata*; *Cenchrus biflorus*; *Cymbopogon*; *Chloris*; *Diheteropogon hagerupii*; *Eragrostis tremula*; *Elionurus elegans*; *Hyparrhenia* sp; *Loudetia*; *Pennistenum*; *Schoenefeldia gracilis*; *Trachypogon*; *Tribulus terrestris*; *Zornia glochidiata*.

The effects of overstocking on biodiversity of grasses and forbs is dramatic. In an area between 0.5 and 5 km from towns and watering points, weed species such as *Calotropis procera*, *Zornia glochidia*, *Tribulus terrestris*, *Gisekia phar-naceoides*, *Cassia tora*, *C. italica*, *C. mimosoides*, *Limuem visocosum* and *Mollugo nudicaluis* invade.

The goal of biodiversity and economic development is to push the annual grassland toward a greater representation of perennials and away from a range of weeds and dicots.

In conclusion, in 1979, donor agencies believed that cattle production could annually grow at 6% per year with a 50% increase in productivity. Only 4 years later, they abandoned this belief. Donors tended to blame the "natural limits of

pasture resources." At present, there is still a strong belief that the best way to increase livestock production is through the stratified approach of grazing young animals on pasture [sic], and then finishing them with agricultural by-products and pasture in the Sudanian zone.

Because of previous failures, donors increasingly have abandoned the Sahel and attempts at range/browse restoration. "Anti-desertification" has become a shibboleth for any project in Mali — even far away from the actual location of degraded grass and shrubland. In addition, work supported by US AID (111) has described the political dimension of the livestock industry in which nine traders and two tanneries control the all the commerce in skins and hides. Pastoralists receive low prices for skins which encourages them to over-stock to achieve equivalent income. There is no re-investment from the sale of skins back into range management. Similarly, the international trade in meat, especially meat products from Latin America, has dampened the market for export cattle to the Ivory Coast and Guinea. The price of cattle for market has fallen and pastoralist economies have suffered. Finally, the ODEM II Project has revealed the difficulty of setting up combined Pastoralist Associations and range management programs. Minimally, pastoralist associations require assignment of land tenure, agreement by all levels of the GOM to "denationalize" (by lease or transfer) the rangelands, and an effective means of enforcement to prevent "outsiders" from trespassing into assigned rangeland or using the association's wells.

Only when these political and administrative obstacles as well as market, re-investment and monopoly distortions are straightened out can restoration of the Sahelian grasslands become effective. At that moment, the pastoralist associations can be assigned the responsibility and provided the financing (nursery stock and technical information) to re-plant shrubs and trees and protect them for long-term "sustainable" production. This replanting will also dramatically increase biological diversity.



B.3 Agroforestry and Biodiversity

Agriculture in Mali is most often combined with other forms of production. It does not exist as an isolated mode of production as found in industrialized nations. It can be combined with forestry, fishing or livestock to increase food security and increase chances of producing surpluses for the market. Without easy access to pesticides, herbicides or fertilizers, farmers rely (when possible) on nature to provide long-term sustainability of their soils. The goal of agro-forestry is to produce as well as conserve.

Biodiversity and agro-forestry connect on various fronts: (1) species selection for nurseries, planting windbreaks, property lines and alley crops, dune stabilization, supplemental forage crops, increased soil fertility and soil moisture retention; (2) natural regeneration and fallow periods; and (3) ecological recycling and termite species.

Species selection is by-far the most important issue. To maximize benefits, trees must have multiple benefits (forage, wind control, property line definition, etc.) and be drought-resistant and productive. Conflicts occur between fast-growing

TABLE II-5: TREE SPECIES IMPORTANT TO AGROFORESTRY BIODIVERSITY(60)

BELOW 500MM RAINFALL

Acacia albida
 Acacia nilotica
 Acacia radiana
 Acacia scorpiodes
 Acacia senegal
 Acacia seyal
 Azadirachta indica
 Balanites aegyptica
 Bauhinia reticulata
 Combretum spp.
 Commiphora africana
 Hyphanaene thebaica
 Mitragina inermis
 Moringo oleifera
 Prosopis juliflora
 Pterocarpus leucens
 Salvadora persica
 Tamarindus indica
 Tamarix spp.
 Ziziphus spp

ABOVE 500MM RAINFALL

Acacia albida
 Acacia nilotica
 Acacia scorpiodes
 Adansonia digitata
 Anogeissus leiocarpus
 Azadirachta indica
 Balanites aegyptica
 Borassus aethiopium
 Butyrospermum parkii
 Carica papaya
 Citrus spp.
 Diospyruos mespilliformis
 Eucalyptus camaldulensis
 Leucaena leucocephala
 Mangifera indica
 Moringa oleifera
 Parkia biglobosa
 Prosopis africana
 Prosopis juliflora
 Psidium guava
 Pterocarpus erinaceus
 Sclerocarya birrea
 Tamarindus indica

species which provide quick-fix success and long-growing species. In choosing the species near or below the 900mm isohyete, drought-resistance becomes an overwhelming concern. Many trees and much labor has been wasted by planting the wrong species in marginal rainfall areas. For instance, the choice of exotics should be limited from the biodiversity point of view. Eucalyptus camadulensis or Leucaena leucocephala may grow rapidly in areas at or above 1000 mm rainfall. But, below, they may grow slower than natives and be more vulnerable to drought. In these situations, they must be planted where there is a reliable water table near the surface.

Most exotics provide shelter to other species. Only a few participate in the food web. For instance, Eucalyptus adds little to soil fertility, reduces microbial recycling within the soil, harbors few insects for reptiles and birds and may prevent other understory plants from growing. It enters the food web only as a supplier of pollen and nectar to bees. From the biodiversity point of view, the degree a plant participates in the local foodweb should be made a criterium of selection.

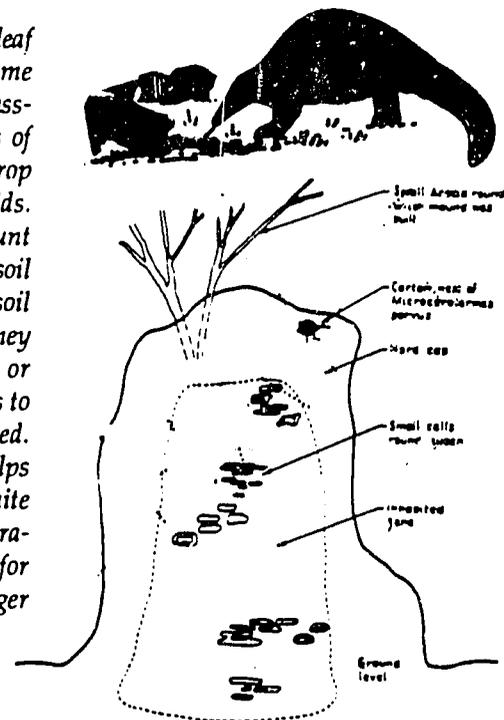
In Mali, the period of industrial plantations of single, fast-growing species is probably ending. Only near Bamako do these plantations make any sense. The new agro-forestry has been slowed by lack of nursery stock, local preferences and prejudices, donor reliance on a few well-known (usually exotic) species, the need to balance fast growing vs. long-lasting species, lack of secure tree tenure for long-growing species, and lack of research to demonstrate the advantages or varieties of trees and shrubs that would be preferable to fast-growing exotics. Some of these barriers to species selection and sustainable agro-forestry will be addressed in the

proposed projects.

Before the 1970s, natural regeneration periods of ten to twenty years restored species diversity near farms as well as provided many wood product needs. Because of drought and increased population pressure (from increased numbers and movement south), the fallow period has been shortened- sometimes to one or two years. A GRM law taxes farmers who clear fallow land after five years. This law encouraged early clearing to avoid the tax. The restoration of longer fallow periods is a biodiversity concern that will be addressed in the next section. Finally, despite donor desires to increase production on rainfed farms for both food security and deceleration of destructive land clearing, total funds for rainfed agriculture projects are relatively low and are decreasing. (US AID in Mali appears to be an exception.) Intensified rainfed agriculture (agro-forestry) could improve the maintenance of biodiversity by increasing natural regeneration times and the amount of "wild" land.

More than any other single project, the review of existing nurseries and the addition of new, especially native species, would benefit both conservation and development.

Termite species eat grass and grass litter, fresh wood and tree leaf litter, decomposing litter and humus and soil. They can consume one-quarter to one-third the litter produced in a savanna grassland. The litter is redistributed as alates (the flying forms of termites which leave the nest each year). Termites are rarely crop pests on rainfed farms but may be pests in irrigated cotton fields. Near termite mounds, grass consumption reduces the amount organic matter in many Malian soils. Some termites move soil from the lower horizons to the surface to form mounds or soil sheets (covered passageways on trees, grass or buildings). They create a non-stoney top to the soil profile. When the mounds or sheets erode they contribute these lower mineralized horizons to the top soil. The importance of this recycling has been debated. Nevertheless, in sandy soils, the termite-transported clay helps farmers by increasing water holding capacity of the soils. Termite mounds also provide shelter for many animals, a microtopography for plant species diversity, scratching and dusting sites for cattle and wild ungulates, and shrubs that provide food longer into the dry season.



B.4 Forestry and Biodiversity

Tropical forest covers 17.4 million ha of Mali (about 14% of the nation). This includes tree savanna, savanna woodlands, tree steppe, dry deciduous forest, riparian forest, bush fallow, tree plantations, village woodlots, palm groves, tamarix drywash, etc. As defined here, it is any grouping of trees within the tropical climatic regions. Following donor and US government definitions, canopy closure and height (important in distinguishing woodland from humid rainforest) have not been considered.

According to the World Bank (55), about 12.9 million hectares of natural forest remain. Given population distribution, marketing conditions, the scattered nature of the Sahelian "forests," and endemic disease areas, only 30% of this area is accessible. In addition, there are legal limitations on harvesting wood within faunal

TABLE II-6: FOREST RESERVES OF MALI BY ZONE (52)

ZONE	RAINFALL (mm)	GROWTH SEASON (days/year)	Area (ha)
South Sudanian	750-1150	120-150	321,623
North Sudanian	550-750	90-120	322,239
South Sahel	350-550	45-90	10,730
North Sahel	150-350	25-45	60,032

reserves and forest reserves. (There is a complete prohibition within the national park.) About 90 forest reserves (forets classes) cover about 715,000 ha (about 4.5%) of all the tropical forests. About 650,000 ha are located within the semi-humid (Sudanian) zone and the remainder in the semi-arid Sahel. All these figures should be treated lightly. Owing to limited GRM resources and growing population, many of the forest reserves are "reserved" only in name. The vast majority have no management plan and vast areas are beyond the control of the limited staff of DNEF.

Mali imports almost all major timber and construction wood. The major depletion of woodstocks in Mali results from firewood. Charcoal is a minor part of this market. It is used to make tea or to iron clothing. Firewood serves for heating, cooking and smoking fish. The depletion of firewood species has been most devastating in the northern Sahelian regions where regrowth is slowest and, after the two extreme low rainfall incidents of the 1970s and 1980s, may be impossible without deliberate reforestation.

Firewood is one "sector" in which the GRM and donors have all agreed on a strategy: (1) fuel-substitution in the urban areas; (2) semi-industrial tree plantations near the cities; (3) improved management of the forest reserves in the rural areas; (4) increased experimentation and research on natural forest management (of which very little is known); (5) the promotion of fuelwood conservation by more fuel-efficient stoves in the rural areas; (6) major revisions of the Forestry Code and administration by forestry agents (54, 59).

Despite this creative and active period, a fuel crisis looms large within the next fifteen years (52). At the moment, wood consumption (including pole and construction wood) is twice the annual accessible natural growth. The prices of firewood are rising and wood exploitation will occur in new areas which were formerly uneconomic to harvest. Unless carefully controlled, environmental degradation can only continue.

What is the role of biodiversity in this dilemma? First, there is a great need to fund natural forest management projects. Little is known of species regeneration times, nursery requirements, planting within existing forest canopies, rotation periods of native species, fire impacts and interactions with other species in the Sudanian and Sudano-Guinean zones. Natural forest management will become increasingly important as wood cutters extend their territory over the next ten years. The "natural forest management" techniques, once established, can be quickly extended in the Sudanian zone and southern forests. At the moment, the only

TABLE II-7: FORESTRY PROJECTS IN MALI

Cooperation Suisse -- natural forest management, training, infrastructure support, marketing of wood products, reforestation (Sikasso).

Cooperation Canadienne -- infrastructure support, small projects in the south, land management, women's group support. (South Mali)

Cooperation Francaise -- DNEF support, forest reserve management, industrial plantations, cartography of forest resources, forestry actions in rural areas (Koulikoro).

Cooperation Hollandaise -- village forestry, agro-forestry, village woodlots, improved woodstoves. (Segou/Koulikoro).

Cooperation Allemande -- local support to Forestry service; "green belt" in Kayes; dune fixation and reforestation (Lake Horo).

Aide Americaine -- reforestation, "anti-desertification" actions such as nurseries, erosion control, *Acacia albida* culture (Vth Region).

Communaute Economique European -- Small forestry work as part of irrigation and waterworks development; technical support to nurseries. (Mopti/Segou)

FAO -- land management, village reforestation, agro-forestry and improved woodstoves in Koulikoro.

Banque Mondiale -- partner in rural forestry near Bamako; construction of DNEF headquarters.

UNSO -- windbreaks, nurseries, village woodlots in lake district; replanting of *Acacia senegal* (gum arabic) forests.

PNUD -- waterworks protection by reforestation (Faguibine) and information center.

IUCN -- protection of *Acacia kirkii* forests of inner delta; natural resource agreements for forest protection; educational journal in Vth Region.

Bureau International du Travail -- labor intensive methods in forestry management; forestry reserves in Kayes.

ONG -- seminars and cooperation.

donor supported projects dealing directly with natural forest management is the Swiss Sikasso Project and the IUCN project in the inner delta.

Second, reforestation projects and biodiversity interlock at the species selection stage of project design. The *P. lucens* example has been given under agro-forestry. Nurseries which produce seedlings of native trees and trubs have not been incorporated into reforestation projects, especially as firewood management. The two most common non-natives (*Eucalyptus* and *Gmelina*) are not the best firewood species. All the projects that include reforestation need review of species selection and additions to the nursery projects (Table II-7). Both DNEF and the anti-desertifi-

cation plan (54) have recommended greater use of natives.

Third, a project which reviews the import of industrial and construction timber and the possibility of long-term substitution by species in Mali would benefit the nation. The West African timber export industry has global markets that are rapidly depleting available supplies (52). The selection of hardwood species and planning for future timber needs have not begun in Mali. In the Sudano-Guinean transition zone important stands of better quality woods such as Khaya senegalensis (dry zone mahogany), Isobertinia doka, Pterocarpus angolensis, Anogeissus leiocarpus, Azella africana and Maesopsis eminii have yet not been identified and nursery, planting, and timber management requirements have not been studied. The Canadians are interested donors active in the Sudano-Guinean zone.

Fourth, all projects that help reduce firewood demand (woodstoves, fuel substitution, family planning) indirectly help forest regeneration and maintenance. Mali is well-known for its successful adoption of fuel-efficient woodstoves. Similarly, the on-going revision of the forestry code, taxes and fine systems will indirectly benefit forest maintenance.

Finally, from the point of view of biological diversity, the importance of dead wood should be reconsidered. In some cases, the decay of dead wood provides increased organic matter to the soil and nutrient concentrations which support important grass and browse species. The root system, even when dead, may serve to maintain soil stability. Dead wood also supports many insectivore birds that may help control pest outbreaks. In one dramatic case, donors sponsored plans for harvesting the allegedly dead trees of the "dead forest" of Acacia nilotica north of the inner delta. They did not want the dead wood wasted. In 1988, rains nurtured a re-leaving of many "dead" acacias -- acacias that had not leafed out for ten years. Donors should be wary of calling Sahelian trees dead without careful inspection. This "dead forest" held sandy soils and dunes intact throughout the two severe drought periods. In short, the complete removal of all dead wood may damage long-term soil fertility and forest regeneration.

KHAYA SENEGALENSIS (Dry Forest Mahogany)

Khaya is sometimes called African mahogany. It is the closest equivalent to American mahogonies. In Mali, plantations began in 1942. But, without long-term nursery and seedling care, plantation results have been disappointing. In full, sunlight, parasites attacked the seedlings. Fires consumed the saplings. Lack of proper shading yielded weak, non-even wood. Khaya is just one of many trees in the Sudanian zone that requires more attention. The tree is also important medicinally and for forage. French: Callicérai. Bamabra: diala. Fulani: dalehi or call.



B.5 Plant Pests and Biodiversity

Fungicides and herbicides have similar impacts to those discussed under the control of animal pests. Treatment for striga, smut, mildew, rusts and bacterial

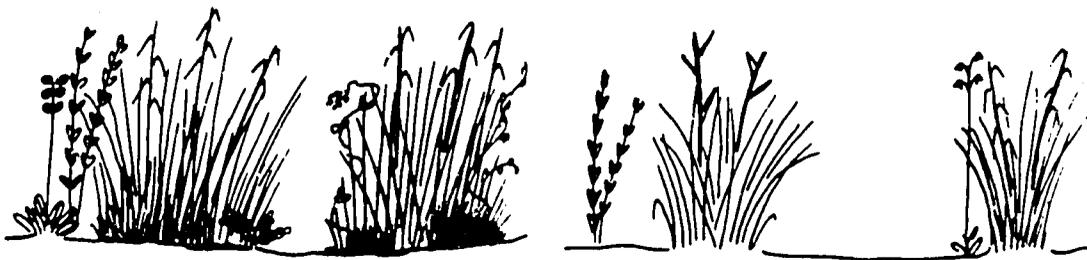
blight are common. I could find no study of secondary impacts of crop fungicides and pesticides on other species in Mali nor of the total quantities of chemical controls used. A complete accounting would be useful for both human health and to pinpoint locales of concern. The accounting would also increase awareness of the impacts of pesticide use on other species.

B.6 Cash Crops and Biodiversity

The cash crops of Mali which have an export component include cotton and peanuts. Sugar cane and tobacco are the major cash crops for internal consumption. Farming methods for cash crops dictate the elimination of biological diversity within crop fields. Cash crop agriculture has had a major influence of the loss of species in the Sudanian zone -- from land clearing and by pushing pastoralists into more marginal lands. Export crops usually require herbicides or pesticides that may further damage non-target species (Section II. A).

According to a US AID sponsored study, a disproportionate amount of donor assistance has gone to irrigated agriculture(14).The owners of the irrigated agriculture have been given tax breaks and credit not available to rainfed or floodwater farmers. This economic distortion directly impacts the available income among rural farmers and, indirectly, leads to a shorter fallow periods and increased land clearing as the only alternative available to maximize income for the family. It also reduces biological diversity and natural regeneration times in the farmer's fields.

The loss of land to cash crop agriculture and rural farming has not been fully acknowledged as an important reason for preserving other Sudanian zone habitats within Mali (e.g., Boucle de Baoule and proposed Bafing National Park). As more and more land is cultivated, these areas will become the only long-term reserves of genetic variety and educational heritage in Mali.



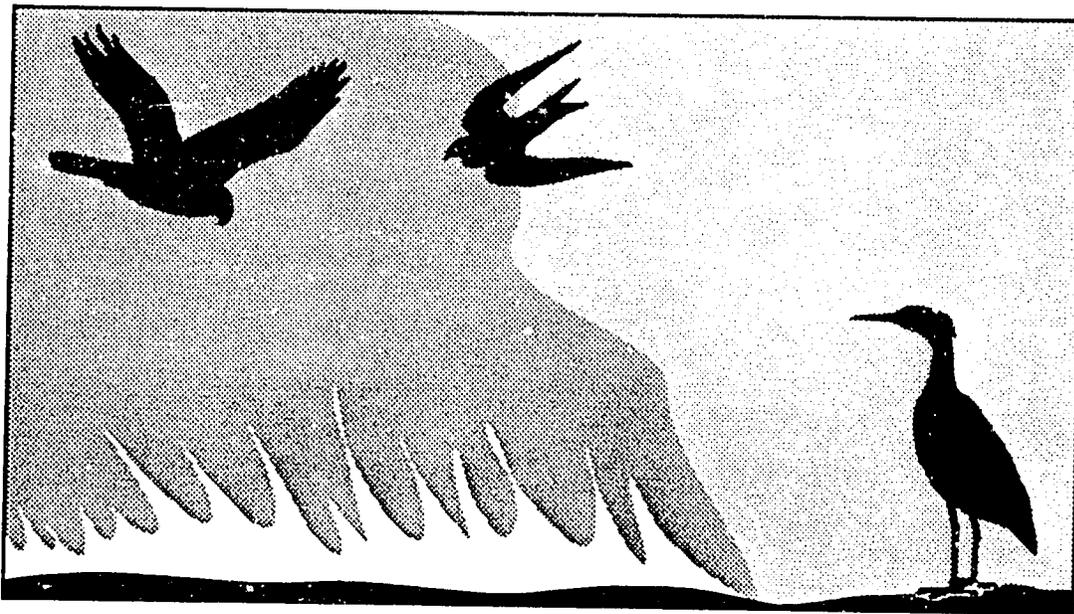
The burnt vs unburnt savanna of Andropogon grasslands. Fires reduce the density of plants, the number of species and the amount of litter (40).

C. FIRE AND BIODIVERSITY

Surprisingly little is known of the immediate (next day), short-term (one month) and long-term effects of fires on the biodiversity of African grass steppes to woodland savanna communities (40). Page 54 summarizes some impacts of fire on species diversity and community composition.

On rangeland which supports greater than 1,000 kg/ha dry matter, deliberate burning is a very low-cost method of creating access to protein rich regrowth. As a single-purpose goal of maximizing short-term livestock production, deliberate fires must be balanced with the long-term disadvantages of burning (reduction of organic matter and straw fodder, soil minerals and soil infiltration, and species variety).

In Mali, despite regulations and government concern, distinctions have not been made between Sahelian, Sudanian and floodplain grasslands. The brushfire codes need revision (Part III). Hiernaux (47) has recommended against burning aquatic meadows. All researchers recommend against burning Sahelian annual grasslands because the resulting wind erosion and water erosion can lead to rapid degradation of grassland. Fires and questions of biological diversity center on the Sudanian, perennial *Andropogon* grasslands. Fires in the Sudanian zone are usually set at the beginning of the dry season to stimulate new pasture for livestock and to reduce damage to trees and shrubs. Hiernaux suggests a rotational fire policy which allows the build up of fuel and the increase of organic matter to the soil by skipping burns one or two years every three. There is little actual experience with this policy. There are no known fire policies set specifically for wildlife maintenance.



The outbreak of fire can provide a feast for birds. The black kite actively searches for grass fires. The West African birds divide up the fire into "niches." Above the flame curtain, kites, grasshopper buzzards, various eagles and hawks, coucals, swifts and swallows capture escaping insects in the air or drop on fleeing rodents. Behind the fire, cattle egrets hunt in the ashes and rollers and bee-eaters hunt from nearby trees. After the flames have gone, marabou storks and pied crows rummage through the ashes. Some birds stay for the day; others may linger for a month. Still others remain as long as the grass is short. The importance of food from grass-fires in the dry-season diet of these birds has not been investigated.

THE ECOLOGY OF BURNT SAVANNA

On a long-term basis, the following generalizations are probably true:

- Fire decreases the number of saprophagous soil animals and their invertebrate predators, mostly by reduction of litter. It favors soil primary producers and soil eaters.

- Fire alters the species composition and occurrence of the Sahel/Sudanian communities by destroying seeds selectively, changing the micro-climate (the soil is more exposed to sunlight) and allowing greater access to livestock (who selectively graze and trample). Fires reduce the shading and moisture provided by litter which favors rapidly germinating plants and dicotyledons over grasses that slowly germinate in moist conditions. These fire-induced changes in biodiversity combine with other influences (rainfall patterns, grazing, local soils) as shown on page 45.

- Fire reduces the number of insects by about 30% in one savanna (Lamto, Ivory Coast). Acridids (which include grasshoppers and locusts) and tettigoniids (katydids) are more numerous in burnt areas. Spiders also become a more important part of the fauna. Cockroaches, lygaeids (seed bugs), pentatomids (stink bugs) and carabids (ground beetles) become relatively less important. In general, species composition changes because the burnt savanna supports less woody material and grass layer nests. The drier microhabitat of burnt savanna favors sun-loving forbs which have special insect predators and pollinators.

- Reptiles and amphibians favor unburnt areas because of the increased year-round moisture and shelter. In non-burned savannas, populations are higher and fluctuate less. Specific species of frogs and frog-eating snakes favor unburnt savanna. Frog-eating snakes may be three times more abundant. "Annual" lizards are not seriously affected by fire, if the fire occurs in the dry season. No studies on long-lived lizards and fire are known.

- The long-term impacts of fire on birds are the reduction of tree nesting, roosting trees and tree fruits. These structural and food differences are part of the general impact of fires which reduce woodland and increase grassland. In the short-term, fire benefits the "fire-followers," bird species who hunt insects chased into the air by flames or exposed in the ashes (see sidebar). Savanna burns change the timing of local movements of a number of inter-tropical African migrants (ie, the biological diversity for particular moments of the year).

- In general, unburnt savannas have larger populations of rodents than burnt savannas. The lower populations, at times, come from fire-hunting of hares and rodents and increased exposure to aerial predators. After fires, the smallest rodents such as mice may explode since competition with larger rodents has been drastically reduced. As with birds, the general loss of trees reduces the number of arboreal and semi-arboreal rodent species (e.g., squirrels).

- Fire benefits many large mammal species, including livestock. Fire reduces tse-tse flies and ticks. Well-timed fires release new, protein-rich grass growth. Elephants once complemented or substituted for fires in the past by uprooting trees and maintaining more grasses relative to shrubs and trees. With the loss of Africa's elephants, fire and tree cutting have replaced elephants as the major strategies to maintain grassland.

D. WATER RESOURCES AND BIODIVERSITY

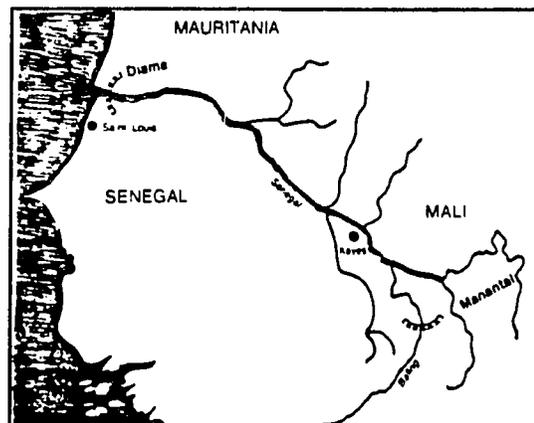
In general, the cumulative value of a river's flood pulse (nutrient supply to floodplain; natural floodwater irrigation; groundwater recharge; fisheries, etc.) has been underestimated. Long-term and sustainable economic interests may be better served by building on the flood pulse and locally flood-dependent production systems (recessional agriculture, floodplain fisheries and grazing) rather than supplanting them. Relying on the flood-pulse or mimicking the flood-pulse by releases from an already existing dam is also more compatible with biodiversity maintenance and traditional social controls (80, 81). Three large water projects in Mali have altered the floodpulse: the Selingue Dam, the Manantali Dam and the Canal du Sahel.

D.1 Manantali Dam on the Bafing River (Senegal River Basin):

Manantali Dam is complete. It is filling. But, practical uses of reservoir waters are not possible. There are no generators nor power lines for electricity. There are hardly any irrigation perimeters that require special irrigation water releases. The Senegal River channel and ports have not been constructed to improve navigation. Without ports or deepened channels, there is no need for water releases to support boat traffic. At the moment, there is really no reason to fill the reservoir. In addition, the rapid filling has prevented the exploitation of in-reservoir timber and wood. Many hundreds of hectares of forests are drowning and the tree resources wasted. This includes some of the best forests of *Borassus* palms whose wood, at times, competes with steel as a desirable, equally priced construction material. The rotted trees remaining in the reservoir will eventually cause localized eutrophication problems.

Fishing remains important in select spots -- especially at the waterfalls where river fish enter the lake and become confused by the stilled water. Fishing is less productive in flooded forest areas and near the dam itself. The populations of hippopotami have plummeted. Impacts on other species (especially chimpanzee) are unknown. The loss of major riparian *Borassus* palm forest cannot be replaced along the fluctuating ("Bath-tub ring") edge of the reservoir.

The Senegal River Basin flows 1500 km from the highlands of Guinea to the ocean at St. Louis, Senegal. In Mali, four of its tributaries enter the Senegal before Kayes. The Senegal is the life source of close to 1 million peasants who depend on flood recession agriculture. It used to be the major riparian and watering areas for herds of Sahelian elephants and other wildlife. The drought and two dams at Diama and Manatalli have hurt fish, waterbird and aquatic mammals badly. None of the mitigation measures suggested by a US AID sponsored study to maintain bio-diversity and their dependent economies have been implemented or funded. (Source: 82,87)



Mitigation measures to compensate for loss of biological diversity have not been funded despite recommendations from US AID. These include (1) stocking the Manantali reservoir with lake fish vs. the river fish; (2) creating a national park adjacent to the Bafing River; (3) building an artificial estuary (Senegal River mouth); (4) repairing waterworks at Djoudj National Park (Senegal); (5) creating low-slope wetlands that could be recolonized by palm forest or other wetland areas at Manantali; (6) starting fish farming projects to compensate for losses. Part IV discusses a possible project for creation of Bafing National Park.

In addition, the reservoir has cut off all access by the DNEF to the areas adjacent to the reservoir that are proposed for protection. There are no forestry agents in the area and access by boat is extremely limited. The remaining riparian, the richest habitat for both human economy and biodiversity, has no protection.

The OMVS did not plan water releases to mimic the flood pulse nor establish a minimum in-stream flow. This has hurt all the floodplain farmers, has caused the collapse of the fishing industry below the dam (especially around Kayes) and has increased negative impacts on all river-dependent reptiles, amphibians, fish, and mammals. It seems odd to this consultant that OMVS continues to fill the reservoir for no economic reason and despite all evidence indicating great economic harm. Again, the value of the flood pulse and in-stream flow has been ignored. Flood-pulse and instream flow water releases are simple aspects of reservoir management. They could begin immediately. They would support both conservation of biological diversity, help the majority of downstream farmers, and benefit the timber harvest within the reservoir itself.

D.2 Selingue Dam and the Inner Delta

Selingue Dam was built before there was concern for analyzing economic impacts of controlled dam releases on the inner delta and ecological impacts on biodiversity. In erratic spurts, the French, US AID and various agencies of the GRM have made small attempts to define the best management practices for the inner delta, including the role of Selingue. Most recently, IUCN has begun a prefeasibility study to determine whether improved management of in-stream flows and water releases from Selingue could increase economic benefits within the inner delta (especially floodplain pastureland, rice and fish production) as well as improve environments for the delta-dependent wild food plants like water lilies and wildlife like waterfowl, manatees, and breeding waterbirds. This project has highest priority for Mali as it best combines biodiversity concerns, food security, long-term sustainability, anti-desertification programs, conservation and economic development (Part IV).

D.3 Canal du Sahel

The consultant did not have time to investigate the impacts of the Canal on biological resources.

E. MINERAL RESOURCES AND BIODIVERSITY

In Mali, gold mining occurs in the southwest. The impacts of mining on river sedimentation and of fishing or hunting bushmeat by miners are completely unknown. The southwest is one of the most isolated parts of Mali but has important biological resources. It has connections through the Faleme Valley to Senegal and Guinea's wildlife populations and has a flora closely related to the Base Casamance.

Other mineral resources (uranium, phosphate, bauxite, manganese, copper and iron) are either potential sources of minerals or have unknown consequences to biological resources. Kaolin excavation in the south has not been investigated.

CONCLUSIONS

In economies such as Mali's with only a few industries and a few value-added products, the biological resources play an overwhelmingly important role. Food, fuel, shelter materials and income depend on the biological resource base. Maintenance and regeneration of wild foods, fuelwood as well as browse and perennial grass species for livestock determine food security and long-term economic stability. To improve the link between biodiversity and more secure household economies, Mali needs to collect and to improve wild crop varieties, develop nurseries for browse and firewood species, plant *Borassus* palm and hardwoods, and implement fish and game management.

In addition, river basin management needs far greater attention and financial support. Proper river management, especially at Manantali dam, would restore economies (recessional agriculture, agro-pastoralism, fishing and wild plant gathering) damaged by dam construction. Income from non-consumptive use of biodiversity (especially tourism) has been largely ignored by the international community and the GRM.

INNER DELTA FISH

The inner delta of the Niger supports 130 species of fish. *Clarias*, *Distichodus*, *Alestes* and *Tilapia* all move laterally with the overflow of the main channel into the surrounding grasslands. Important subsistence and commercial species like *Alestes* grow in size and weight only during these periods of high water. "False" floods from a seasonal release of reservoir water from Selingue have triggered "false" lateral migrations. After one navigation release, thousands of *Alestes* became stranded in the floodplain before they had the opportunity to reproduce. River basin management is crucial to fisheries economic production. *Alestes* is called *bere* (Bamabara), *dyava* (Bozo). Bottom drawing of air-breathing *Protopterus*. SOURCE: 21.

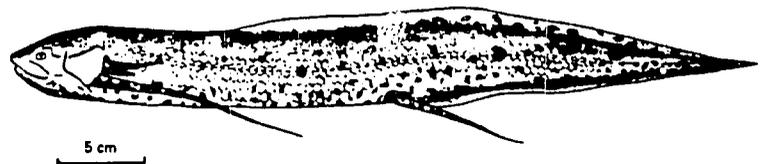
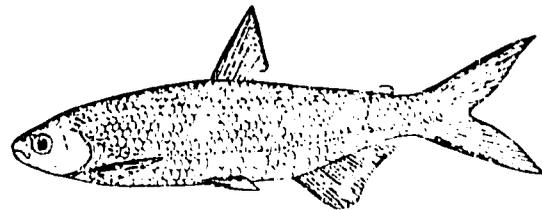
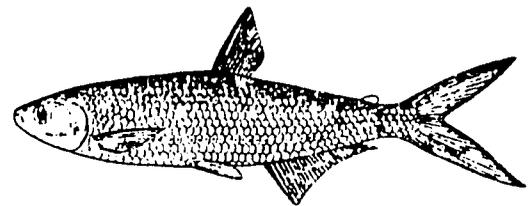


TABLE III-1: WAYS OF INFLUENCING BIOLOGICAL DIVERSITY

International Influences:

- Treaties and Conventions
- Multilateral and Bilateral Agreements
- Donor Aid

National Influences:

- Monitoring programs
- Research Programs
- Legislation, laws, codes and regulations
- Policy Statements
- Implementing Institutions (national, regional, parastatals)
- Coordinating Institutions
- Enforcement Programs

Economic Influences:

Direct — fees, royalties, rewards, grants, income supports, guaranteed markets, subsidies, loans, wages, food-for-work, buffer zone access to natural resources, special access to surpluses within protected areas, material goods for doing something or doing nothing.

Indirect — Fiscal measures such as tax breaks, loan guarantees, tariff or price supports, debt swaps on a national level.

— Provision of services: health care, transport, grain storage.

— Social Organization: land tenure agreements, access agreements, community development agreements, special training, education programs, land banks, revolving funds, compensation funds, credit, grants, etc.

Local levels:

- Family
- Village Councils
- Maitre d'eaux, maitre de foret, dioros
- Religious leaders
- Local law enforcement agents (forestry agents, judges, police)
- Schools

**PART III: SOCIAL, POLITICAL AND ECONOMIC INCENTIVES
TO MAINTAIN BIOLOGICAL DIVERSITY IN MALI**



WALIA is the best educational magazine produced in West Africa. It serves the Vth Region of Mali. It has reconnected generations by giving them common topics of interest to discuss and stimulated projects and thoughts about combining conservation with household production. The project, under the direction of Monique Trudet, is supported by West Germany with cooperation from DNEF and IUCN.

The section considers all kinds of human activities that can influence the maintenance, restoration or destruction of biological diversity in Mali (Table IV-1). These activities can serve as incentives which protect and maintain biological diversity; disincentives which deter, warn, dissuade or frighten citizens from destroying biological resources; and perverse incentives which encourage the destruction of biodiversity (1). These incentives, disincentives, and perverse incentives can occur on any level: international treaties; national legislation; local enforcement by customs agents, forestry agents, judges or police; corruption; community groups; religion; schools. Of course, given the time allotted, this section can only point to those that came to my attention. There exists a need for a more detailed study of the administrative structure and legislation concerning biodiversity. A more complete survey of projects, sponsors, and their relevance to biological resources is also needed.

A. INTERNATIONAL

The international community has three major interests in biodiversity in Mali: compliance with international conventions; maintenance of the flow of goods which rely on Mali's biological resources (e.g. palm hearts, Eurasian waterfowl, hides); and the provision of an educational, aesthetic, and pleasurable outlet for its own citizens ("tourism"). In addition, the international community may be interested in preserving certain plant species that may, in the future, contribute to the global economy such as medicinal or wild crop varieties of plants ("option value") or certain species such as the Gourma elephants or giant eland that its citizens feel are important to have alive on the planet ("existence value").

The GRM has signed the African Convention for the Conservation and Management of Wildlife and Its Habitat, the African Convention on the Conservation of Nature and Natural Resources, and the Convention Concerning Protection of the World's Cultural and Natural Heritage. It has signed the RAMSAR agreement on wetlands but has not set aside any RAMSAR sites. All these international agreements act as positive incentives to protect the nation's biological resources.

The GRM has not yet signed CITES(Appendix III) which is the main international treaty controlling the export and sale of endangered and threatened species. Because of the increased trapping of chimpanzees, the poaching of elephants and hippos for ivory, the legal trade in wild birds, and illegal trade in reptile skins with Europe, the signing of CITES is important. Any international aid to protect areas with endangered species should probably require the signing of CITES as part of the bilateral or multilateral agreement. In addition, the international community can assist Mali by monitoring or sponsoring up-date meetings to insure that Mali has adhered to the conventions and treaties it has signed. Mali is in need of such a review.

During the last ten years, the international community could have provided many more incentives to conserve biological resources. Grants, loans, and technical aid have not had a conservation component, or the conservation components have received no significant, sustained funding. Interest and funding have been erratic, crisis-oriented, and reactive. This has had a particularly devastating effect on Mali during the current period of rapid historical change. The drought, population movements, population growth, and a sinking economic situation have accelerated losses of habitat and species. A few examples:

— Multilateral aid to the Manantali Dam Project (from West Germany, Saudi Arabia, and the US) included no obligatory actions on the part of the OMVS, Senegal or Mali to mitigate damages to biodiversity and no funding for mitigation. Dam

construction was a waterworks project without any conservation incentives. Some have considered the project a perverse incentive because it encouraged destruction of wetlands, river palm commerce, instream habitat, fishery production, Sudanian woodland and significant wildlife without any financing to conserve these habitats.

— UNESCO (76) designated the Boucle de Baoule a Man and the Biosphere Reserve but provided too little funding, too late to save the more important species within the national park. RURGS (78) funded a serious analysis of wildlife and hunting potential in the OPNBB. But, with no follow up, the populations declined drastically and the report is no longer applicable. Having no other material, the GRM and donors still use this out-of-date report to guide them on park management.

— UNESCO, responding to the drought crisis, funded a quick survey of the Gourma elephant herd (76,78). But, six years later, there is still no follow up.

In the past few years, there are encouraging indications of change. In 1986, FAO presented and adopted Le Plan d'Action Forestier Tropical (PAFT) which has provided a stimulating conceptual framework and goals for DNEF. The Swiss have altered their program to incorporate natural forest management and to fund a revision of the Forestry, Wildlife, Brushfire and Fishery Codes. US AID has set standards for use of pesticides and worked with the GRM on questions concerning secondary impacts of the Locust Control Program. US AID has also added family planning to its health program. The West Germans (with a small US AID contribution) have funded IUCN's program to write natural resource management agreements among different producer groups in the inner delta and have funded WALIA, the best educational project concerned with biodiversity. DNEF, the Norwegians and IUCN may start work on multiple use agreements for the Gourma to protect wildlife and sustainable pastoralism.

In conclusion, donors have not yet incorporated biological diversity into development assistance, nor acted in a timely manner nor provided long-term (eight to ten year) funding for preservation projects. Insuring compliance of all donor countries to international conventions which include Mali and the donor (e.g. Spain and Italy and wildlife skin imports; wetland and hunting protection in Europe for migratory birds) is necessary to avoid donor hypocrisy. Three border areas need particular attention: the influx of Mauritanian hunters who export wildlife jerky from Mali; the Gourma elephants that spend time in Burkina Faso; and the Faleme Valley with species (elephants? giant eland? chimpanzee?) that may require habitat in Mali, Senegal and Guinea. In addition, water rights, water releases, in-stream flows and wetland and fisheries protection, involving all the nations of the Niger and Senegal river basins, will eventually need resolution.

B. NATIONAL

The droughts of the 1970s and 1980s overwhelmed the capacities of the GRM and the nation's natural capital. They also focused attention on the need to conserve biological resources. As resources became scarcer and increasingly over-used, the need to create a new legal framework for access and use of wildlife, wild plants, grazing lands, fish and forests became apparent. Conflicts and confusions between traditional or customary laws, Islamic influences (particularly Dina laws in the inner delta), colonial laws and post-independence legislation have just begun to be aired. Mali is a nation open to serious change.

The national levels of the GRM and biodiversity interlock at many points:

— The national government can coordinate sectors of the economy in areas of resource management. It can re-organize agencies. It can add biodiversity to the water development, public works (e.g., roads) and tourism agencies. On large projects or donor-supported projects, the national government can require environmental and economic impact assessments.

— The national government can set standards, codes, and guidelines for regional and local communities. It can make itself an example to be followed.

— Policy can act as an incentive and support for regional and local management of biological resources. For instance, tax breaks for fish farms or crocodile culture can be combined with stricter regulation of fish net sizes or hunting.

— The national government can encourage the business community to pay attention to biodiversity concerns through incentives or disincentives. The business community plays a crucial role in balancing long-term sustainability against short-term gains.

— The national government can support education, research and training with a biodiversity component. It can influence religious leaders to consider these questions with their followers.

B.1 National Policy

Mali has no national conservation strategy. Biological diversity concerns have been somewhat pigeon-holed in DNEF (Table III-2) or included in projects only when donors insist. Many sectors, especially rural development, primary and secondary school education, irrigated agriculture, large water works and road construction have not incorporated a conservation strategy.

The national incentive on the policy level can be found within the anti-desertification plan (PNLCD). Although the plan could narrowly focus on the advance of degraded grassland and desert-like landscapes in the Sahel, the scope of the plan has become nationwide. The PNLCD is essentially acting as an umbrella for all small-scale natural resource management projects. The plan's policy statements have just been translated into 8 programs and 49 projects. A few have a specific biodiversity component (Table III-3). Feasibility, detailed definition, cost estimates and financing have yet to be concluded. The PNLCD is an ideal program to inject concerns for biological diversity.

B.2 National Standards and Guidelines

All the standards and guidelines for biodiversity concerns are under review. The Wildlife Management Code (Code de Chasse) needs up-dating on all species since most larger mammals now need much more protection, some species are extinct, and others do not live in Mali. In addition, the rules for hunting need revision. Mali's geography is too diverse to exist only on legislated, national regulations. Each region needs its own standards because populations have become patchy and some regions need more protection than others. Finally, the Forestry Agents cannot possibly patrol the areas assigned to them. There is a need to incorporate Hunter Associations into the code and give them responsibility by, perhaps, deputizing some hunters in exchange for access rights.

TABLE III-2: NATIONAL IMPLEMENTING AGENCIES CONCERNED WITH BIODIVERSITY

Ministry of Natural Resources and Livestock
 Department of Water and Forest Resources
 Semi-Autonomous SubDivisions
 OPM OPNBB OAPF OARS
 Technical Services
 Environment
 Project Programming
 Water and Soil Conservation
 Reforestation
 Wildlife and National Parks
 Fisheries and Aquaculture
 Personnel and Equipment
 Regional Offices
 County Offices
 Forestry Posts
 Division for Forestry Research
 Station de Recherche Sur Les Plantations Irrigues
 Station de Recherche Sur La Biologie des Essence Autochtones
 Project d'Inventaire des Ressources Terrestres
 Centre de Technologie des Bois de Savane
 Le Laboratoire d'Hydrobiologie a Mopti
 Institut National de la Recherche Zootechnique, Forestiere et
 Hydrobiologie
 Organisation Traditionnelle des Chasseurs
 Organisation Traditionnelle des Exploitants Forestiers
 Organisation Traditionnelle des Pecheurs

Union Nationale Democratique du Peuple Malien (fire control):
 L'UNJM, L'UNTM, L'UNFM (improved woodstoves, tree days, and urban planting)

Compagnie Malienne de Developement des Textiles
 Direction Nationale de l'Agriculture
 Direction Nationale de la Cooperation
 Direction Nationale de l'Elevage
 Direction Nationale de l'Interieur et des Collectivites Territoriales
 Direction National des Services Judiciares
 Direction de la Surete Nationale
 Etat Major de la Gendarmerie Nationale
 Office Malienne du Betail et de la Viande
 Service des Domaines
 Direction Nationale des Impots
 Operations de Developpement Rural (ODR)
 ODIPA PRODESO PFRS

Institut d'Economie Rurale (research)
 Ecole Normal Superieure
 Institut Polytechnique Rural

Office du Niger (irrigation agriculture)

TABLE III-3: PROPOSED PROJECTS WITHIN PNLCD WITH BIODIVERSITY COMPONENTS

Project 21 (II Program): new national parks, faunal reserves, sylvopastoral reserves, reforestation, agro-forestry and zones of limited use.

Project 25: a center to coordinate projects but remains specific to forestry projects and does not include actions of other sectors.

Project 22: a new Centre National d'Etudes et de Recherches sur la Desertification. It is not clear if this will absorb IER and INRZFH. It may focus on forestry but has set as a goal the inclusion of more native tree and, hopefully, shrub species.

Project 25 (VI Program): In OHV, DNEF will control land clearing and integrate livestock with agriculture.

Project 26: ODIPAC will reforest, promote fuel efficient stoves.

Project 28: ON will reforest, introduce biogas and fuel efficient stoves.

Project 38: PRODESO will start nurseries, reforestation and fight brushfires

Project 39: Lake Zone of UNSO will start nurseries. Species unknown?

In parallel, the Brushfire Code needs to be written by regions. In Sahelian (annual) pastures and bourgu pastures, the existing regulation prohibiting all brushfires should remain. In the Sudanian zone, brushfire regulations could allow a three-year rotation system which includes a single year of early dry-season burning (47).

The Forestry Code and its administration need up-dating (54,59). Many Forest Reserves are now tree plantations or farms. Other areas with special forests (e.g., the dry evergreen forests) have no representation in the forest reserve system. Review of Forest Reserves and plans for management can incorporate biodiversity components and deserve donor attention.

The Forestry Code can provide more incentives and fewer disincentives by:

- establishing cutting limits by region;
- better definition of the "public domain" vs. private and village domains;
- reconciling usufruct rights with customary rights;
- incorporating special regulations for sylvopastoral areas;
- establishing long-term government leasing of sylvopastoral lands in exchange for obligatory management and reforestation;
 - removing many repressive aspects (disincentives) and replacing them with incentives (e.g., local responsibility and control) or directed punishment (e.g., limiting monetary fines, reforestation labor vs. monetary fines);
 - writing real appeal procedures for contested tree tenure;
 - training forestry agents in education and writing simple informative pamphlets or producing cassette tapes on reasons for regulations.

TABLE III-4: SOME NATIONAL LAWS INFLUENCING BIOLOGICAL DIVERSITY

Loi 86-42: Forestry Code (Code Forestier)

Loi 86-43: Wildlife Management Code (Code de Chasse et de Conservation de la Faune et de Son Habitat)

Loi 86-44: Fisheries Code (Code de Peche)

Loi 86-46: Law Requiring Fuel Efficient Woodstoves (Obligatoires l'Installation et l'Utilisation d'un Foyer Arne'tore)

Loi 86-65: Land Clearing Regulations and Taxes

Loi 60-4: Firearms Code (Le R:gime des Armes et des Munitions dans la Republique Soudanaise)

Loi 86-66: Fire Code (Code de Feu)

Plan National de Lutte contre La Desertification

The Land Clearing Code contains one section which particularly hurts natural regeneration and biodiversity maintenance. It taxes land clearing, if the land has been fallow more than five years. Farmers have responded by clearing in three years (to insure that the Forestry agent doesn't claim that a four year fallow is actually five or more years).

The Fisheries Code does not protect any particular species by size. This might be a useful addition to the code because enforcement can take place in the market place. I could find no listing of fishery reserves. The mesh size needs to remain large. Fishing in the inner delta has not allowed young to escape and stocks have increasingly decreased in size. Fish traps are now under discussion.

Disincentives such as severe punishments for violations as well as the methods of enforcement are considered repressive by many Malians. The ambience is not conducive to conservation under forestry agent guidance. For instance, fear of forestry agents stopped fishermen from informing a IUCN scientist on the locations of manatees in the inner delta. The manatee population could not be estimated nor a management plan written. As described earlier, the inequitable treatment in which Bamakois and influential individuals have access to game hunting (64), while local poor residents are punished, undermines existing law. The most important incentive may be insuring that forestry agents, the army and permittees from higher levels of the GRM set impeccable examples of lawfulness.

B.3 Economics

The economics of anti-desertification and protection of biological diversity necessitate an initial investment in a community and the provision for payment of recurrent costs. Part I (C.3) discussed the problems of major concern to forestry agents — delayed salaries forcing them to impose fines for their livelihood. The inability of the GRM to pay and deliver these recurrent costs in a timely matter is at the root of many of the national implementation of resource management problems.

BIODIVERSITY AND ECONOMICS IN MALI

This consultant is always asked : Is it profitable? Will the project produce greater income? Simple questions. Very complex answers. First, projects concerned with biological resources are long-term projects. Results may not be accountable for ten or more years. They are investments in future generations as well as present-day populations. Many passive benefits (hydrological and land stability or increased soil fertility) elude the economic evaluation process. In particular, "option value" (the value that some species may be economically profitable in the future) completely escapes economic calculation (1).

Second, many of the benefits of protecting or maintaining biodiversity have difficult monetary equivalents. Many products are for local consumption (e.g., fish, wild grains, household game meat) and never enter the market economy nor the monetary accounting system set up by analysts. These "food security" items do not participate in exports, though they can reduce imports or the size of donor food programs. In Mali, economists have not entered many locally consumed items in the GDP or in "replacement value" calculations (e.g., money saved by donors who do not need to deliver emergency food aid). In fact, economic analysis for food security and/or protection of rural assets (especially livestock) may significantly differ from economic analysis focused on increased productivity and profits. The first addresses risk avoidance and maintaining stability. Many biodiversity concerns in agroforestry, fisheries, and all forms of pastoralism fall into this category. The second economic activity addresses risk assumption and non-equilibrium gambling for higher production and profits.

Example: Biodiversity and Risk Assumption. The short-term economic value of the Gourma elephants is their weight in ivory. Their extinction would also increase certain crop harvests previously eaten by elephants. On the other hand, they are the last Sahelian herd. Over time, their "existence" or "rarity" value will definitely accelerate. Long-term economic benefits include: a sustained population with managed culling of ivory; a tourist-attraction with its multiplier effects (hotel, guides, transport, near-by "package-tours" to Mopti, Timbuctou and the Dogon); and non-monetary values such as cultural pride, helping fulfill inter-African conventions, and education. The immediate costs are: setting up the park, resolving conflicts between rural citizens and park needs, integrating local citizens into the park economy, creating an anti-poaching team, tourist hotels, advertising, etc. This might cost \$6 to 8 million (US) over 6 to 10 years. The park system would then pay its own recurrent costs. At this point, "rates of return" and long-term economic "costs or harm" vs. "profits or benefits" leave economists speechless. Nevertheless, once established a national park mammal can bring in enormous income (e.g., an Amboselli lion equals \$27,000 of tourist-related business). Mali and the donor community have not yet been willing to risk this level of investment for long-term economic and biodiversity regeneration.

A revolving fund that stabilized timeliness of salary payments is an economic incentive that might remedy this situation.

The inner delta has had a net dis-investment because money leaves with the traders and, even when taxed, does not necessarily find its way back into the inner delta economy. Re-investment in exploited areas is a crucial aspect of maintaining biological resources and providing an incentive for local communities to protect biodiversity. The GRM might consider, for instance, "conservation" taxes on hides and skins that would go to restoration of sylvopastoral lands. Or, the GRM might drop taxes on families that re-plant trees on village or personal lands. There is a need to mesh economic incentives with conservation of biological resources in order to achieve a more equitable distribution of profits as well as local re-investment in resources.

B.4 Research

The exact status of research in Mali was a bit confusing. The research monies for biological diversity (with the exception of certain wild varieties of food plants) have foundered. Both donors and the GRM recognize the need to experiment before plunging into large-scale projects. The PNLCD includes test areas in which restoration programs can be tried and monitored before making major financial commitments. The PNLCD includes a new anti-desertification research center. Funding is not yet secured.

Many of the best reports such as M. Diallo's on the use of wild animal products in Bamako (63) have not led to policy changes or to new incentives or disincentives. There has been no follow-up on good research nor funds to continue work. The most outstanding work by Pierre Hiernaux (12, 13, 45, 46, 47, 84, 85, 86), funded by ILCA, on species and productivity changes during the drought has been terminated within the inner delta. This work led to clear recommendations on bourgu grazing patterns, seed depletion, fire policy, and restoration policies crucial to the PNLCD. To drop this funding after ten years is, in part, to throw out knowledge just when each year added the most information. Continuation of Diallo's and Hiernaux's work has been given high priority for donor funding (Part IV). Additional research work connected with wildlife management has been incorporated into other projects. Fisheries monitoring in the reservoirs and inner delta as well as experimental fishfarms also need further funding.

B.5 Education and Training

I did not have time to review the incorporation of biological diversity into educational and training programs in Mali. There is no general text on conservation, ecology and development for Mali. L'Institut Polytechnique Rural at Katibougou trains Forestry Agents (52). The biodiversity component is unknown. The Vth Region has the best Francophone program for elementary and secondary schools in West Africa — the IUCN/WALIA Project. Other regions have no programs. DNEF would like to add a forestry curricula to other areas and sponsor a mobile classroom (p.c.). Various agency directors expressed the need for their programs to include training elements on biodiversity. For instance, the CPS would like to add a class on the secondary impacts of pesticides on wildlife to its training curriculum.

An obvious need in a country in which literacy may be as low as 10% is the use of film and video to stir up ("animer") interest and increase awareness "(sensibiliter") among the public. Films and video on questions of energy efficient stoves, endangered species, wildlife products, biogas substitution, soil conservation, and food production in local languages and in French could accelerate environmental awareness. A textbook, popular audio-visual information and increased training provide strong incentives to better biodiversity management.

B.6 Religion

The relation of religion to biodiversity has not been widely explored. While the Islamic religion rejected "sacred groves" and forests, it did not interfere with local customs concerning care for forests. While it promoted hunting, it protected species that Muslims cannot eat. Under the regime of Sekou Amadou, sacred forests disappeared but land use and livestock management rules were established which the people of the inner delta still respect. Sekou Amadou decreed that individuals who harmed Acacia albida would be severely punished.

There are Muslim groups in North Africa that have incorporated tree conservation into Islamic ethics. Religion provides a major motivation and incentive for sacrificing short-term gains for long-term benefits. A promised haji to Mecca in exchange for caring for a 100 trees for 20 years would be a major family incentive to grow and protect biological resources (4). A conference on religion and conservation in West Africa would be useful.

C. LOCAL LEVELS

Local implementation is the crux of all natural resources management, including biodiversity. On the local level, national policies must be defined to fit the many micro-habitats and cultures of this very large and diverse nation. Mali is going through a very exciting period of its post-independence history. The structure of responsibility is devolving more and more to local levels. The customary or traditional rules as well as rules from the Dina (Islamic) period are increasingly mixing with post-independence legislation. There is a search for the proper role of "village chiefs," "maitres d'eaux," "maitre des forets," dioros, et al in national resource management and protection. The process will be painful as various interest groups try to monopolize or gain greater shares of forest, pasture/browse, fish or international donor resources. A few examples:

— Various peasants have complained that particular individuals with the complicity of administrators have usurped their land in order to receive the benefits of international aid. Others have complained that DNEF has given special concessions to private individuals within Forest Reserves.

— In the Gourma, the Toureg pastoralists lost almost all their herds in the recent droughts. Norwegian aid has helped them settle and become farmers in the inter-dune marshes. The Toureg want to preserve the Gourma elephants ("if they disappear, so will we") but sedentary agriculture conflicts with elephant conservation even more than pastoralism.

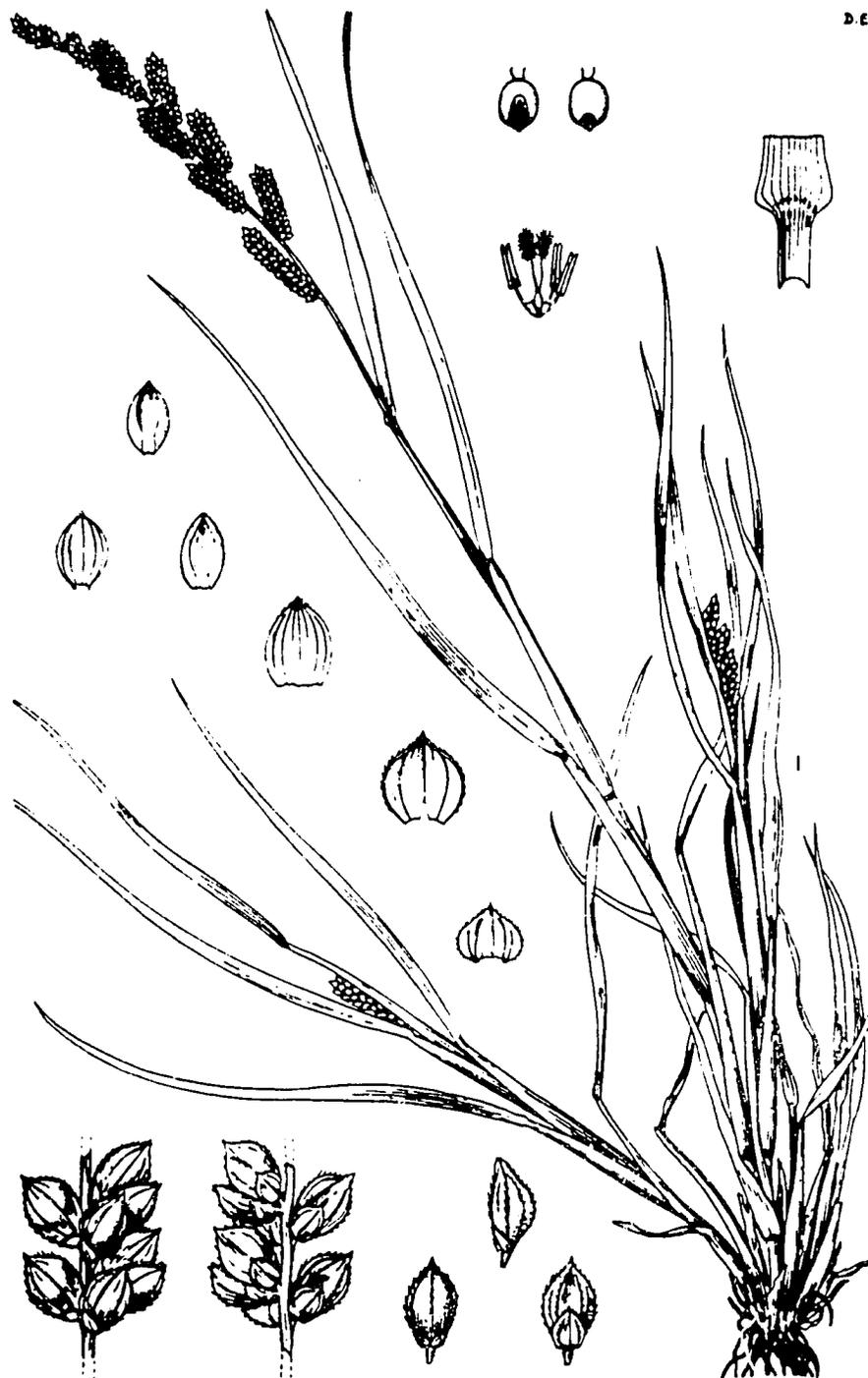
— In the inner delta, IUCN worked out agreements that would set aside forest reserves for all interested parties (fishermen, land owners, pastoralists, conservationists). But, confusing administrative overlaps, the agreement of outsiders, and the multiple layers of authority have made complete agreement and enforcement impossible at this time (88).

— In the inner delta, Bozo fishermen agreed to a larger mesh size and a no fishing area to allow fish populations to rejuvenate after drought and over-fishing depletions. The local authorities agreed to a ban on the smaller mesh nets but merchants who sell the nets and non-resident fishermen refused to obey the rule. Who and how will the regulations be enforced?

— The ODEM II project formed Pastoralist Associations which exchanged secure pasture rights for reduced grazing pressure. The PAs agreed to pay 10% of all new watering point development. But, again, outsiders were not included in the agreement and the PAs had no enforcement power to keep them out.

All these examples show that economic incentives and secure access rights can be traded for better maintenance of biological resources. Sample incentives can be found in Table III-1. But, shifting the structure of responsibility to lower levels, also requires shifting the power of enforcement and/or establishing legal recourse for the enforcers. The IUCN work on facilitation, reconciliation, information gathering and networking is probably the most important work for long-term sustained conservation and development. All proposed biodiversity projects include this component (Part IV).

PART IV: PROJECT PROPOSALS AND US AID



D. E.

The *Echinochloa* grass complex is an important part of the livestock and drought fallback production systems. The grasses are essential to any range improvement, food security and anti-desertification programs in the Sahel and delta regions. The "species" shown above is *E. colona*, an annual. It may be the genetic source for Japanese barnyard millet. It is grown for forage in the US and for grain in India, China and Japan. In Mali, *E. stagnina*, a perennial aquatic, is the crucial food for transhumant pastoralist herds crossing the delta. Its leaves are even harvested and sold as forage. During famines, humans eat the seeds. Hiernaux (86,88,89) has worked on its ecology and care. But, no seed collections and selection of improved varieties for food or forage are known. Collection and cultivation improvements of wild and weedy plants in Mali should be a high priority project. Illustration from 29.

TABLE IV-1: SUMMARY OF PROJECT PROPOSALS/ PART I

Preservation of Ecosystems and Species

Priority Projects:

Proposed Bafing National Park
Proposed Gourma National Park
Re-Development of Boucle de Baoule National Park
Signing Appendix III, CITES

Ecosystem Projects:

Inventory of Asango Menaka Faunal Reserve (p.18)
Location and Classification of Evergreen Dry Forests (p.11)
Inventory remaining Guinean and Riparian forests (p.11)
Inventory of the Adrar des Iforhas (p.16)
Projects to fulfill RAMSAR requirements(inner delta projects)
Education projects to increase awareness of ecosystems, species
and the importance of biodiversity through videos, TV and
movies (IInd Region, Bamako)
Hold a conference with West African religious leaders on natural
resources and ethics (p. 67)

Species Projects:

Revision of the Code de Chasse (p.65)
Limiting cross-border hunting from Mauritania (p. 61, 83)
Train and fund an anti-poaching team
Stopping illegal export of animals through Guinea
Coordination of Malian Plant Collections and Herbaria (p.30)
Development the Arboreta and Zoo with national species

Throughout this report, actions to protect and maintain biological diversity have been described. Table IV-1 tabulates projects concerned with protection. Table IV-2 tabulates conservation development projects that include a biodiversity component. The distinction between "conservation development" and "biodiversity preservation" is only a matter of emphasis. All of these projects include strong components designed to assure local residents of food security and sustainable livelihoods.

Since there is no room to describe all of the projects, the reader should refer to the appropriate text listed in the Tables. In Part IV, we describe five "priority" projects. "Priority" signifies a project with strong a biological diversity component which will require significant long-term financing beyond the capabilities of the GRM. The signing Appendix III of CITES, the revision of the Code de Chasse, and the termination of poaching from Mauritania and Guinea are hardly less important. But, the GRM can work on these goals without donor financing or with small project, short-term aid.

Section C discusses US AID CDSS priorities and mission financing in order to provide a more realistic picture of the possible US contribution to biological diversity in Mali over the next five years.

A. PRIORITY PROJECT PROPOSALS CONCERNED WITH ECOSYSTEM AND SPECIES PRESERVATION (TABLE IV-1 & APPENDIX)

The three priority projects for ecosystem and species preservation are identical with those discussed by M. Sanogho, Director of DNEF. Details of these projects can be found in the Appendix.

A.1 Proposed Bafing National Park

The proposed project will take eight years to complete. It will require international actions by the GRM to stop poaching and sport hunting as well as a commitment to CITES. The park in combination with Bafing Reservoir water recreation could become a tourist attraction that would earn park management recurrent costs in the future. The first phase requires an inventory of species present, their distribution and seasonal movements. The second phase would define boundaries and write agreements for access and use by surrounding villages. A park plan would be prepared. Phase three would require donor funding of infrastructure and relocations (if necessary) of villages. Costs have not been determined. Details of conflicts, needs and proposal phases are included in the Appendix.

Bafing is the last relatively intact Sudanian woodland with rare and endangered international species (chimpanzees, Derby's eland) and national species (African buffalo, waterbuck). OMVS and donors contributed to the reduction of biological resources and diversity in the proposed park area by constructing Manantali dam. Consultants sponsored by US AID recommended the park as an important mitigation measure. US AID funded the human mitigation measures but not the ecological measures. There has been no donor interest so far.

A.2 Proposed Gourma National Park

Gourma has perhaps the most potential of any area of Mali to attract tourist

TABLE IV-2: SUMMARY OF PROJECT PROPOSALS/PART II

Conservation Development with a Biodiversity Component

Priority Projects:

- Land Tenure and Natural Resource Management Agreements
- Management of Water Releases from Selingue Dam
- Manage Manantali for flood pulse and instream flows (p.55)
- Revise Fire Code (p. 53, 64)
- Revise Forestry Code (p. 65)
- Revise Land Clearing Code (p. 65)
- Review nursery production and species selection for sylvopas
toralism and agroforestry needs. Fund trial plantings with
promising native species (p.46 -51)
- Expand the PNLCD into a National Conservation Strategy
- Coordinating Collection and Trials of Wild Food Plants(p.41)

Research Priorities:

- Fund Natural Forest Management Research and Trials
- Fund M. Hiernaux's Malian counterpart to continue monitoring
sites in the inner delta and the Sahel (p.66)

Conferences:

- Hold Conference on Incorporation of Biodiversity into Donor
Projects
- Discuss re-investment economics of the inner delta

Plant Resources:

- Management Guidelines for Classified Forests
- Revise Protected Plant Species in Forestry Code, include P.
lucens
- Review timber imports and possibilities of timber self-suffi
ciency
- Continue support of projects to lower firewood demand
- Review recurrent costs and salary problems within DNEF

Continued on Next Page

TABLE 1V-2 CONTINUED

Animal Resources:

- Joint-power agreements with Hunter's Associations (p.34)
- Organize Hunter's Associations and marketing of wildlife parts in Bamako Area (p.34)
- Enforce Controls on Commercial Wildlife (p.34)

- Revise Fisheries Code (p.65)
- Stock Manantali with Appropriate Fish(p.55)
- Inventory fish stocks and needs for fish farms and restocking
- Reconcile water rights and instream flows for Senegal and Niger River Basins (p.55-58)

Pesticides:

- CPS proposals to destroy dangerous pesticides and build residue testing lab and increase training program(p.39)
- Inventory types and locations for total usage of chemical applications (p.51)
- Add land use management to onchocerciasis control program(38)

Biodiversity and Tourism:

- Package tours with a wildlife component and help fund infrastructure (p.40, see Gourma/Bafing projects)

Education:

- Continue WALIA and expand to other regions. Incorporate TV, video and movies into program, especially in cities.

income through viewing of elephants and other Sahelian species (lion, ostrich, gazelles). It is near-by Mali cultural attractions such as the Dogon villages and Timbuctou. The "centerpiece" of this multi-goal tour would be the last Sahelian herd of West African elephants.

The project's first phase would study elephant needs and movements and form a joint working group to plan livestock development, health services, watering points, land tenure and international cooperation. The GRM must commit to signing CITES and upgrading a "new" Gourma to national park status. Phase two would fund agreements, services, anti-poaching team and infrastructure for the park and the legal and diplomatic work necessary to sign a cooperative agreement with Burkina Faso.

The project could be done in five years. Costs have not been determined. At the moment, the important players are IUCN, ODEM, AEN, DNEF, the Tamsheq,

Burkina Faso. The project is outside US AID's geographic focus but the health services, veterinary and forage aspects and technical services of OSTA may provide a link to US AID programs. (More details are given in Appendix.)

A.3 Re-Development of Boucle de Baoule NP and Adjacent Reserves

The OPNBB complex is a Man and the Biosphere Reserve that has been badly degraded from lack of action. The OPNBB will require restructuring to create an integrated complex of forest reserves, biological reserves, relocated villages, buffer zones with game management, and natural resource agreements. The FAO and ADB have sent a prefeasibility team which estimated project costs at \$1 million US for five or six years. It is not known if this includes re-introduction of extinct species. Players include resident villagers, Peul transhumants, poaching Mauritanians, Bamakois hunters with special permits, DNEF, IUCN, FAO, ADB. The project is within the US AID geographic focus (II region) and has integrated rural development themes. More details in the Appendix.

B. PRIORITY PROJECTS FOR CONSERVATION DEVELOPMENT WITH A BIOLOGICAL DIVERSITY COMPONENT (TABLE IV-2)

B.1 Land Tenure and Natural Resource Agreements (Inner Delta)

IUCN's Phase I has ended. This research phase reported significant discoveries on the importance of natural resources within the delta to five distinct production systems and demonstrated in detail the paramount importance of legally enforceable natural resource agreements (Part II, D). The second phase will include actions designed to regenerate woodlands, bourgu pasture, wild grains as a drought-fallback food supply, and crop production. It will include seed banks, credit systems, and transport systems for grains (both wild and domesticated). IUCN will help with management committees that include outsiders, traders, DNEF and with political committees in order to broaden the participation and improve enforceability of natural resource agreements. This is perhaps the most important work on the local, regional and national levels in Mali. If it is successful, a method for reconciling Mali's confusing mixture of traditional, Dina, colonial and post-independence laws will be available. IUCN will set up an office in Bamako to assist the development of this new structure of responsibilities.

This IUCN project is considered the highest priority for conservation development since the results could be far reaching and could establish a method of implementing a national conservation strategy. Funding for the project requires two persons for two years to work on land tenure issues as well as funding for the Bamako office. Land tenure experts from the University of Wisconsin agreed to the project. US AID tried to find fall-out funds for the project. The project, as of January 1989, remained without funding. US AID has a commitment in the Vth region for village reforestation and from previous work with ODEM. US AID might consider funding part of the wild foods and food security project through ICRISAT and SAFGRAD.

B.2 The Best Management Practices for Water Releases and Diversions in the Inner Delta

The closing of the Selingue Dam (on the Sankarani, a tributary of the Niger above the delta) resulted in reduced water levels in the delta in 1982, 1983 and 1984. ORM became concerned that upstream development was seriously compromising its investments in rice cultivation. SOGREAH, a French consulting firm, built a simple computer model which estimated that, in 1985, 1 to 3% of the flood height could be ascribed to the dam. In 1985, Niger accused Selingue of causing the Niger to dry up at Niamey.

Because the inner delta is the heart of Mali's economy and includes important habitat for fish, aquatic mammals and birds, IUCN started a pre-feasibility study to determine how changes of flood height, duration and timing affected the floodwater economies of pastoralist, farming and fishery production. The project's ultimate goal will be managing water releases for the most beneficial instream flows and artificial flood pulse for the delta's economy, national hydropower, instream navigation, Office du Niger agriculture and Mali's wildlife heritage. The management plan will include an early warning system for farmers, herders and fishers. The early warning system would inform the farmers of the predicted floodwater height and save them the labor of planting crops destined to fail. It may allow farmers to plant the crop that will bring in the most income. The EWS will forewarn herders of the best crossing dates for their cattle and allow fisher families to anticipate dates of lateral fish migrations and locations of expected fish concentrations. It will help Mali fulfill its RAMSAR responsibilities (Part III, A).

This is a high priority project because any improvement in predictability and flows within the inner delta has huge consequences on the economy. River basin management, more than almost any other single action, influences more production systems on a larger scale. Conservation development and biological resources are tightly interwoven. US AID's interest could be part of this long-term project (Appendix), especially as US AID has spent over \$350,000 trying on an unfinished project with a similar goal. Players include ODEM, OPR, IUCN, SCF, ILCA (?), ORM, Office du Niger, OMM, DNEF, SAD, CAC, and others. PIRT is an excellent Malian organization for land use mapping.

C. US AID FINANCES AND BIOLOGICAL DIVERSITY

Mali is a Category I country for natural resource management and biological diversity. The Mission will spend, at least, 10% of its annual budget on natural resource projects. This may or may not include projects with a biological diversity component. In general, natural resource expenditures have averaged about 5.3% of the total US AID budgets in Sahelian countries (110, 114). Mali's US AID OYB budget has varied between about \$12 and 19 million US (\$7-20 are extremes). Total foreign assistance to Mali ranges between \$200 to 350 million so that the US is not a major direct contributor. (Additional US assistance arrives through multilateral contributions and food programs.) If 10% of the OYB budget is spent on natural resource management, the the natural resource budget (again, not necessarily the biological diversity budget) should vary from \$1 to 2 million each year.

US AID's goals have focused on promoting economic growth and food security through policy reform, institution-building, technology development and transfer. At the same time, the health sector has been a growing concern. In short, the

CDSS for FY 90-94 targets three priorities: economic growth, hunger and malnutrition, and mother/child health deficiencies. The parts of the CDSS that could address biodiversity concerns are species selection within the agro-forestry program, the proposed fisheries/livestock research and training institute, and the addition of wild grains to the new crops cereal project (OHV, SAFGRAD, ICRISAT). Other non-priority areas of interest to the mission have been mentioned: PVO development, women in development, private sector development, town market development, education, and natural resource management.

The mission has tried to narrow its portfolio and geographic spread. Most projects take place in the IInd Region with "oddball" projects in the VIIth (PVO buy-in on integrated rural development) and the Vth region (village reforestation and IUCN natural resource management). IUCN received \$150,000 from the Washington fund.

The mission has followed up on the Africa Bureau's policy statement "Supporting Natural Resources Management in Sub-Saharan Africa." A natural resource management review of successes in Mali, Senegal, Gambia and Niger has been completed (112) as well as an action plan for Mali. The mission administratively supported this assessment. The action plan which has a biodiversity component received funds from the US Africa Bureau. The US AID Mission Director has been active in monitoring the use of pesticides in the locust control program. The mission attempted to find fall out funds for IUCN's land tenure project which is a pioneering effort to combine natural resources management with biodiversity protection.

Given the relatively low priority of biological diversity within the budget of the next five years, the main recommendations for significant funding from the mission can only be part of the 1994 to 1999 CDSS. Until that time, funding can only come from: central Washington (DFA, Sahel Special Projects, African Bureau or Office of Science and Technology); multilateral banks; buy-ins to bilateral, PVO and NGO and local currency projects; on-line studies; or, perhaps, it can be combined with food aid and transport. Some of the Washington funds will be coordinated and reviewed by another office of Biological Diversity now forming in Washington (113). All of these will be relatively small commitments. Perhaps, the only hope for a larger commitment comes from the "fall out" funds from other missions or through influencing expenditures by multilateral banks (ADB, World Bank, IMF).

Given the limited funds available, it appears that the US AID mission cannot make a significant commitment to any of the priority projects in Tables IV-1 and IV-2. However, it is possible that US AID could do the following:

- continue to serve as a significant quality control agency for the State Department and Treasury Department on multilateral projects and projects such as the Nosema biological control project which have private US contributors.
- attempt to influence OMVS to quickly set a release schedule from Manantali Dam and implement mitigation measures recommended by US AID documents (e.g, reservoir fish stocking);
- incorporate biodiversity concerns into the World Bank forestry projects and review the inner delta master plan which is World Bank funded;
- insure that its own projects such as village reforestation nurseries, livestock research on forage production, new crops, agricultural policy reform, rain-

fed agro-forestry, etc. have fully considered species selection in the project design and implementation stages;

— assist IUCN's new office that will coordinate natural resource management projects and will aid the GOM in writing a national conservation strategy;

— continue to emphasize family planning within the child/mother health and nutrition projects;

— make ready project proposals which focus on biodiversity in order to grab "fall out" funds as they come available (especially the two year land tenure project of IUCN);

— fund some of the smaller technical aspects of projects like the inventory surveys of the proposed Bafing or Gourma National Parks or M. Hier-naux's monitoring/training project on drought impacts on forage production;

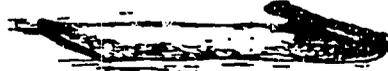
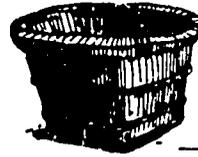
— select a major project concerned with biological diversity for the next CDSS.

Mali has been a country heavily damaged by the drought and an over-centralized economy. US AID has helped Mali move toward food security, decentralized economics and environmental stability. Consideration of biological resources and diversity are new to both US AID and the government of Mali. It is hoped that this report makes the conceptual and practical goals clearer and that biodiversity can be tangibly incorporated into Mali's evolving culture, ecology and economy.

THE PEACE CORPS AND BIODIVERSITY

US AID will not have significant finances in the next five years to help Mali in large projects. Other US organizations, especially the Peace Corps, could help in this area. In other nations, the Peace Corps has become an active player. For instance, in Botswana, a retired park service official is helping train citizens to manage Chobe national park. In Morocco, a peace corps worker taught tracking and population census techniques to Moroccans in a project to locate the last leopards in the Mediterranean. In Mali, the Peace Corps has focused on agriculture and rural health. It needs to add more work on wild food and craft plants to its agriculture, grains and handicraft programs -- including the collection of seeds, cultivars and the regeneration of useful wild or weedy species. It needs to emphasize natural regeneration of forests in its forest program. The Peace Corps can include a knowledge of biodiversity in the agroforestry, forestry, and gardening training programs. But, more important, a plan to employ Peace Corps workers in direct actions adding conservation education, regeneration of natives in nursery programs, training of wildlife managers, etc. The Peace Corps has expressed enthusiasm for these goals and between writing and publishing this report, it may have already begun.

Avec les feuilles, on fabrique des objets très utiles. On en recouvre en certains endroits le toit des cases.



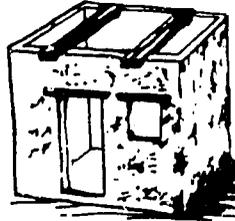
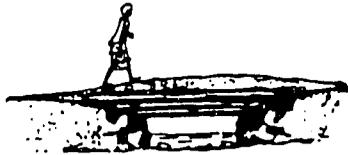
fruit



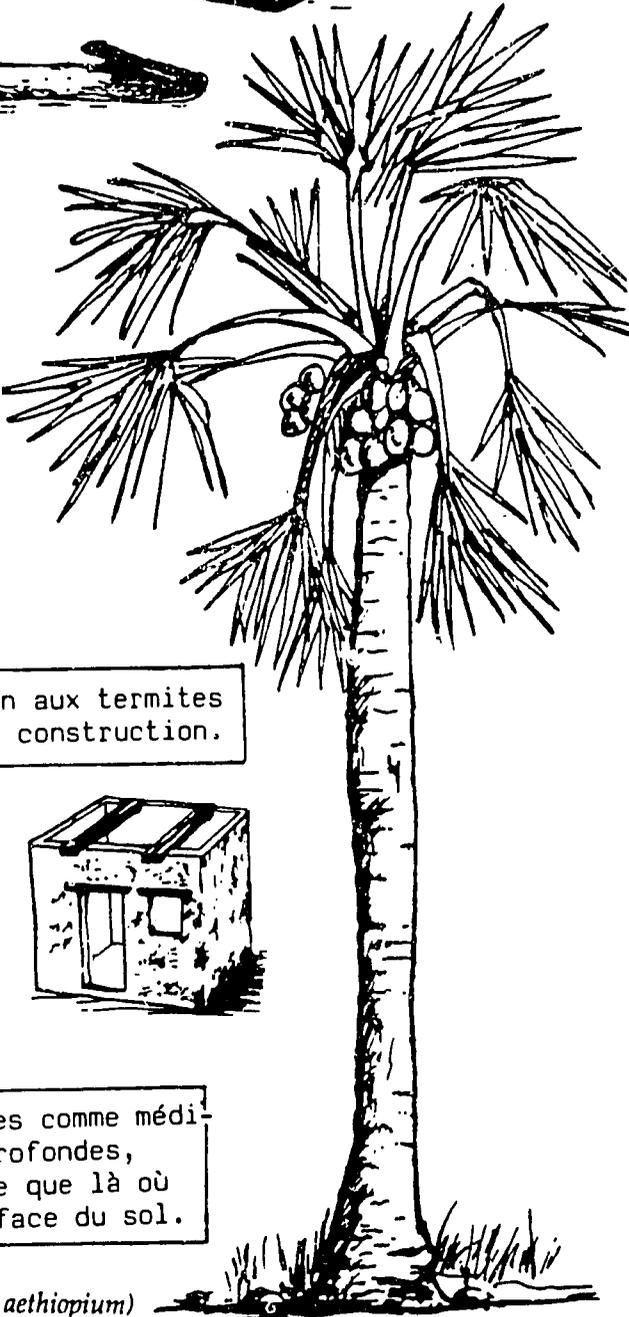
graine germée.

On mange les fruits cuits et on en tire un bon jus. Avec l'amande dure et blanche à l'intérieur de la noix, on fabrique des boutons et des petites sculptures. On mange également la graine qui a germé, le sébénikou ou dissi.

Le tronc résiste bien aux termites
On l'utilise pour la construction.



Les racines sont utilisées comme médicament. Elles sont peu profondes, alors le rônier ne pousse que là où l'eau est près de la surface du sol.



RONIER or BORASSUS PALM (*Borassus aethiopicum*)

A tree needing on-site protection for the first ten years. Needs low moist sites with more than 800 mm rain per year. This much desired palm has been reduced by lowered watertables (drought); illegal cutting (its wood brings prices equal to imported construction steel); harvesting of young buds (palm hearts) which kills the tree; and brushfires. When elephants were common, they destroyed many trees in pursuit of its fruit. The growing tip of the palm is also attacked by a fungus. Recently, the reservoir behind Manantali dam drowned one of Mali's most extensive and rich *Borassus* palm forests. The palm supports both humans and other animals (the palm-nut vulture, chimpanzees). But, humans rely most on every part of this tree for home construction (beams and roofing), palm wine, fiber nets, food, cooking oil, sweet drink and many medicines. For long-term, sustained construction wood, food and biodiversity support, the borassus palm should be much more widely grown and protected.



APPENDIX OF PROJECT DESCRIPTIONS



The section gives more details of the four priority projects that contain a biodiversity component .

PROJECT: INNER DELTA

Note: Background material on the delta is included in sidebars in Parts I and II. Although far from exhaustive, some details have been included because the delta is the highest priority project.

Reasons for Project

1. The inner delta is one of three of the most important wetlands in the Sahelian zone and one of the top ten wetlands in all of Africa. It has been selected by Mali and the international community as a RAMSAR location.
2. The inner delta has the most varied habitats of any community in Mali. It has the highest biodiversity in fish (130 species), migrating birds (both intra-African and inter-continental), resident waterbirds, and wild plant germplasm (floating rice, fonio, etc.).
3. It is the most highly productive area of Mali with the most varied and inter-locked production systems. It is crucial for economic security during drought years because low rainfall can be partially mitigated by floodwater irrigation.
4. The inner delta has the best baseline data of all areas in Mali on livestock, bourgou ecology, vegetation changes and desertification, conflicts between tradition and national administrative structures, child and mother nutrition, economic strategies for survival, hydrology, etc.
5. Much of this data remains uncoordinated and previous investments such as US AID expenditures on river basin management (1983 to 1985) have not been utilized for increased productivity, conservation of natural resources or for resolving biodiversity concerns.
6. There is great tourist potential in the inner delta with boat trips to Timbuctou and Mopti as well as birdwatching.
7. Djenne, within the delta region, is one of GRM's test zones and the GRM (with World Bank funding) has begun work on a Master Plan for the delta region.

Overall Goals of Projects within the Inner Delta:

1. Improve water management to increase farm, fish and pastoral productivity and protect aquatic species (fish, birds, remaining mammals) by establishing an early warning system that predicts flood height, duration and area.
2. Improve land management, soil conservation and plant (grass, tree, forage) usage by creating natural resource agreements between conflicting production systems, establishing firmer rights to land and fishing areas, and reducing conflicts

between national administrative structure (especially Eaux et Forêts) and traditional systems.

3. Address biodiversity concerns, especially RAMSAR, through water management and land tenure concerns.

4. Ultimately, write a conservation strategy for the delta that relates productivity and land tenure and water management to all the various administrative agencies.

Specific Projects:

A. WATER MANAGEMENT

Three goals: an awareness tool, actual management strategies and an early warning system.

PHASE I: THE FLOOD AND PRODUCTIVITY

Varied flooding can increase or decrease productivity within the delta by 10 to 12 times. There has been no impact on the influence of Selingue Dam and release scheduling on flood heights, duration and area. Many studies have done partial investigations (SOGREAH, US AID, IUCN, ORSTROM) but no useful results have emerged. Phase I of the project would produce:

1. The relation of flood height to flood area and the relation of flood timing to flood duration and flood area by analysis of satellite photographs and recorded flood flows.

2. The economic and biodiversity consequences of normal, dry, very dry, wet and very wet years and the consequences of two or more consecutive years of low flood. A discussion of rainfall's relation to productivity within the area where rainfall and natural flooding overlap.

3. An analysis of the SOGREAH and the US Army Corps of Engineer models for determining flood height and area. A review of all topographic material and gage stations that might contribute to a better understanding of productivity, biodiversity and water management. Establish a "library" at IUCN office in Bamako.

4. A narrative discussion of "type years", instream flows and biodiversity, navigation, fishing and downstream (Niger) conflicts; the effects of upstream diversions to Markala slough and of storage capacity of Selingue on the inner delta's productivity; the possible conflict between hydropower needs and productivity within the delta; consequences of varied flood regimes to each of the five major productive systems.

5. A narrative discussion of all the linkages required to establish a water management agreement for the delta.

6. A review of Malian water policy from the point of view of instream flows, water rights, priorities, etc.

7. A review of the technical ability of Selingue Dam to become a multi-purpose dam as originally intended in Malian legislation.

PHASE II: WATER MANAGEMENT PROJECT:

1. EARLY WARNING SYSTEM DEVELOPEMENT WHICH WILL INCLUDE:

- a. Extension and communication including a radio station that can spread news of flood arrival and areas to be flooded.
- b. IUCN monitoring of human responses to EWS and accuracy of predictions at various points within the delta.
- c. Coordination with hydrological predictors (Office of Niger?, ORSTROM?) to determine accuracy of model and gauging system.
- d. Determining of warning times needed by each productive group including cattle-crossing dates, crop choices, planting dates, etc.

2. RELEASE SCHEDULING

Actually reconciliation and discussion with various interested parties of Phase I results. How to utilize hydropower, navigation releases, Niger water rights, Seingué storage, Markala sluice diversions, OPM needs, ORM needs for maximum productivity and economic stability. Begin to establish priority release schedules.

3. RELEASE SCHEDULING

Begin writing what will become legal agreement among agencies and interested parties to allow river basin management.

PLAYERS: IUCN (Sahel Program) as coordinator. REDSO (Abidjan) for review of US AID materials in Niamey and Vicksburg, Miss. ODEM. DNEF. Others?

TIMING: IUCN has begun part (1). Phase I will take two to three years.

COSTS: Phase I, Part (1) about \$40,000. If landsat can be aquired cheaply by US AID, costs are greatly reduced. Parts (3), (5), (6), and (7) as can be separate contracts. Costs unknown but should range from \$7 to \$20,000. Part (4) costs unknown.

B. LAND TENURE AND FISHING RIGHTS IN THE INNER DELTA

IUCN has completed its research phase on the inner delta (see Part II) and is about to launch its implementation phase. Below is an interpretation of the project from a point of view that emphasizes biodiversity. The overall project is for natural resource management and increased productivity. Space does not allow a complete discussion. This discussion is to help donors target aid to biodiversity components.

1. LAND TENURE NEEDS TO IMPROVE NATIONAL RESOURCES MANAGEMENT

This is the project that includes the University of Wisconsin Land Tenure Center. It has been under consideration by US AID for two years. It is an action program to develop land tenure agreement that will allow efficient and fair use of soil, water and plant resources. These include the great diversity of wild food and craft plants (fonio, water lillies, borassus palms) which have been over exploited during drought and poor nutrition years. As emphasized in the introduction, almost all

production groups are dependent on the diversity of plant species for extra income, economic stability, fallback food security or income to buy grains in shortfall years. The funding for this project is considered by this consultant of highest priority. It is for 2 persons (ex-pat plus counterpart) for two years.

2. FORMATION OF MANAGEMENT COMMITTEES

The experience of trying to create protected forests for waterbirds that will also be sustainable resources for grazers, herders and fisherman met obstacles because outsiders had not been included and administrative boundaries set up confusions about proper authority and who will receive what benefits. Really inseparable from the above land tenure project, this project focuses on the formation of local management committees and their success and will provide the model for all other conflict resolution work in Mali (eg. Boucle de Baoule, Bafing, Gourma). They are the only real hope for protection of biodiversity of birds and aquatic birds and aquatic mammals within the delta. As above, this should have highest priority. Costs are being determined by IUCN.

3. REGENERATION OF RESOURCES

With the drought and mass movements of people to the south, there has been a need to regenerate lost or degraded resources. This is part of the struggle against desertification and for food self-sufficiency. It has high national priority. Its biodiversity component includes regeneration of bourgu, tree crops, rangeland species and the collection of wild food germplasm for field testing of differences in productivity and adaptation. The collection and field research on wild grains is a priority for improved family nutrition and falls well within US AID goals.

4. ECONOMIC INTERVENTIONS

Playing the market place is an adaptive strategy for survival within the inner delta. Credit systems, grain storage, transport for buying/selling (skipping middlemen) and seed "banks" for years of low production are all ways to protect against famine. The biodiversity component focusses on transport. Many areas of the delta could harvest excess wild foods and make palm-leaf mats and trade them for badly needed seed stock or supplement cereals. Credit systems that encouraged harvesters to transport their products by buying their own boats would increase food security. IUCN will develop costs of this action program which falls well within US AID's economic reform and improved nutrition goals.

5. LONG-TERM SUSTAINABILITY AND BIODIVERSITY

The most thorough work on species composition and changes under various rainfall regimes has been done in the inner delta under the direction of Pierre Hiernaux. This is by far the best work in the Sahel on biomass production, species diversity, seed storage in the soils (potential for regeneration) and effects of the timing of storm events on diversity and productivity. ILCA (Hiernaux's support) has moved to the south — abandoning (like many donors) the more difficult Sahelian regions. This project would cost between \$10-20,000 per year and would include training and overseeing a Malian counterpart to continue monitoring vegetation and productivity changes in the sites established by Hiernaux. This is one of the highest priority projects both for training, understanding Sahelian range conditions and drought, and developing a better understanding of natural fluctuations in species composition (vs. human influences) in the Sahelian zone.

6. OTHER PROJECTS: THE BAMAKO OFFICE

Although listed here (under the inner delta), the IUCN OFFICE in Bamako, is also a high priority for funding. This will be the only office that can easily coordinate work on NRMS and biodiversity concerns. Its goals include: (1) a liaison to GRM ministries which will be increasingly involved in NRMS agreements especially on water management, the formation of local management committees and changes in the code de la chasse and code Forestiere; (2) writing with the Malian government an overall conservation strategy; (3) coordinating information on biodiversity projects with the ministries and the "lutte contre le desertification;" (4) serve as a library for education of the public and donors on concerns about biodiversity and NRM; (5) perhaps have the computer network (modem) for updating of projects under the NRM's contract with the Washington, DC directory and newsletter.

PROJECT: BOUCLE DE BAOULE NATIONAL PARK

Reasons for Project:

1. Designated a Man and the Biosphere Reserve by UNESCO (1982)
2. A national priority of the GRM and DNEF.
3. Close the Bamako with greater possibilities of tourism.
4. The first attempt in Mali to create an integrated reserve of reserve forests, a biological reserve, buffer zones, game management, and natural resources management agreements with resident and transhumant population.
5. Baseline data (maps, some sociological, ecological and infrastructure studies) already available.
6. An unknown amount of Sahelian-Soudanian, Soudanian/Guinean and riparian forest still in good condition.
7. Can be considered part of GRM's fight against desertification.

Conflicts and Needs in Project Development:

1. There are no large mammals left in the Biosphere reserve. The giant eland, elephants, African buffalo, hunting dogs and some species of antelope have disappeared. The priority as a national park is greatly reduced. Reintroductions are a long-term possibility except for elephants which would conflict with extensive sedentary agriculture in the area. Reintroductions are expensive and could be considered in perhaps five to ten years.
2. Hunting (poaching) is a present uncontrollable. Urban hunters, Moors, local subsistence hunting and even forestry agents, will need to come to an enforceable "contract" with limitations of game hunting and modifications of hunting code.
3. Natural resource agreements with transhumant grazers (Peul, Fulani, and Moors) will be required to protect any biological reserve and manage the park's grass and forage resources. The Moors, being outsiders will be particularly diffi-

cult to incorporate into a legal agreement.

4. There may be a need to move or "condense" hamlets and villages (approx. 5,000 people).

5. The management of the Park requires restructuring (control is now in Bamako), decentralizing and better coordination with all agencies involved. There has been encroachment of peanut growers and millet growers. The legal basis of land tenure for village forests and cultivated lands will need clarification. The system of Eaux et Forêts fines will need great modification.

6. Boundaries will need to be redefined with specified buffer zones and a biological reserve.

7. Funding will necessarily come from donors. Mali does not have the financial resources. A consulting team estimated that immediate needs would be about \$1 million US for each year for five to six years. There is some urgency if the project is to be successful as the longer it is postponed the greater encroachment and abuse.

Project Phasing and Donors:

The FAO and ADB have sent a team to look at the possibility of creating an integrated reserve with land tenure, access and use agreements. They hope to interest IUCN. US AID interest would be geographic (much of the reserve is within the Iléme Region) and concerned with agricultural and rural development. The project would probably not be funded by US AID until the next CDSS period, although US AID might make small contributions to specific aspects such as training game wardens.

PROJECT: GOURMA NATIONAL PARK

Reasons for Project:

1. This is the last remaining viable population of elephants in Mali; the northernmost viable population in Africa; and the only Sahelian elephant population known.
2. Protecting the elephant herd could also protect many other Sahelian species such as ostrich, lion and gazelles.
3. The area has great tourist potential as a multi-purpose tour with access to Timbuctou, a Niger river trip, or the Dogon country.
4. It is among DNEF's top three priorities for protected areas.
5. It has been given high priority by the IUCN committee on elephants and rhino protection.
6. The Tamaheqs do not poach elephants and have expressed a desire to protect them. They have a need for livestock aid (watering points, vaccination) and health and literacy.
7. Some groundwork has been in place through the AEN (Norwegian Church

Aid) and Mike Winter. There are few settlements, at the moment, that would interfere with the creation of a park or more complete reserve.

Conflicts and Needs in Project Development:

1. During the drought, elephants come in conflict with livestock at waterholes. Because of the devastating consequence of the drought, many Tamasheqs lost their herds and are now turning to sedentary agriculture (with the help of AEN). Their gardens are within the marshes that elephants visit.

2. Conservation of elephants will require coordination with Burkina Faso — the wet season habitat of the herd.

3. The GRM has not shown compelling interest at the highest levels. It has not signed the CITES, appendix agreement. The Code Chasse still allows elephant hunting and the GRM has not prohibited trophy hunting in the Gourma. They have not agreed to create a national park.

4. Poaching by Arab emirs, the military, local subsistence hunters and even Eaux et Forêts agents has been reported. While the reserve is only for elephants, the future tourist and conservation goals will require extension of management for beyond existing conditions.

Project Proposal and Donors:

PHASE I.

1. The first need is to inventory the elephants (their numbers, seasonal movements, border crossing areas) in order to establish the viability of creating a park, a no hunting reserve, define the park's boundaries and migration corridors.

2. The GRM must sign CITES and express a high level of commitment (including upgrading the faunal reserve, modifying the Hunting Code, etc.)

3. A joint group of ODEM, AEN, DNEF, biologists, representative Tamasheqs and local administrators need to be formed to plan agreements concerning livestock development, health services, watering points, and land tenure rights.

PHASE II.

Establish a permanent presence of Eaux et Forêt in the area; define road systems that will confine tourists; define boundaries and rules for access by livestock and hunting; furnish Eaux et Forêt with necessary equipment, work with Burkina Faso on their conservation needs; create tourist facilities; implement livestock aid, human services and organization to enforce access and use agreement.

PLAYERS: IUCN, ODEM, AEN, DNEF, Tamasheq, Burkina Faso. US AID commitment is weak both geographically and, in terms of major goals. Participation would require a strong shift by Mission to participate. Costs have not been estimated.

PROJECT: PROPOSED NATIONAL PARK ALONG BAFING RIVER

Reasons for Project:

1. This is the last relatively intact Soudanian/Guinean woodland and forest in Mali. It is the northernmost point of chimpanzee distribution — an internationally endangered species with great interest to research workers in human evolution. The Bafing area is the driest area known in which these close relatives to humans still exist. The Bafing area supports Mali's the last viable population of the Giant eland (Derby's eland) and African buffalo. It includes other four primates (galagos, patas, baboons, vervets) and antelope (roan, kok, waterbuck). This area is considered part of the center of Sudanian species richness by IUCN.
2. Many of the villages have already moved because of the presence of Manatalli Dam. Because of its relative isolation, poaching has not been extreme (but see below). Livestock has not greatly modified the landscape because of the tse-tse fly.
3. The dissected plateaus with isolated buttes and occasional monadnocks include some spectacular scenery. The presence of Lake Bafing makes tourism attractive for both watersports, fishing as well as wildlife viewing.
4. The park is one of DNEF's top three priority protected areas.
5. The river area, from the biodiversity point of view, has been devastated by the dam and reservoir and village relocations. OMVS, in a US AID sponsored report, recommended the park as a way of compensating for the loss of spectacular riparian (borassus palm) habitat and wildlife within its watershed.
6. The Boucle de Baoule National Park is empty of large mammals and invaded by livestock. The Bafing offers the only chance for Mali to create a national park that was not a colonial inheritance (a French hunting reserve).

Conflicts and Needs in Project Development:

1. There has been no inventory that describes the species present, their distribution, density and their seasonal movements. Before spending large amounts of money, this inventory is required.
2. There is a need for greater motivation on the highest levels of the GRM. There is a need to sign Cites, Appendix III; modify the hunting codes; and to commit to a conservation strategy that includes protected areas.
3. There is a significant poaching problem within the general area of the proposed park. Moors poach for dried jerky; locals for the subsistence; dam construction workers for trophies and meat; the army for extra food, even Eaux et Forets agents have been reported hunting. In addition, there appears to be a trade in wild game through Guinea to Spain. Agreements that limit or stop hunting will be difficult to obtain with the outsiders and even more difficult to enforce.
4. There is no Eaux et Forets presence in the proposed area. The road access is near impossible until late December and stops again by June. Boat access is difficult because roads have either been flooded or do not connect to the reservoir. The post in Manatalli is cut off from the proposed park.

5. A few towns and hamlets would either have to be removed or condensed.
6. There is need to make a decision quickly or Bafing will follow the fate of the Boucle and there will be no large mammal reserves in Mali.
7. There is no infrastructure for park management nor tourism.
8. Although there is no real reason to store water in the reservoir and no release scheduling plan, the reservoir continues to flood riparian and adjacent forest at a rate that most wildlife cannot adjust to. The palm-nut vulture, hippos, reptiles, waterbuck, and perhaps the chimpanzee populations are suffering greatly. The lake is flooding the best scenery (the water falls) unnecessarily.

Project Proposal:

PHASE I.

1. Establish a research station (temporary) within the proposed park area. Hire two research workers (one ecologist and his Malian counterpart) plus two to four DNEF technicians for 18 months to two years. During this time, an inventory of wildlife, special habitats, migration, corridors, etc. will be defined in order to create ecological boundaries for protection of the species, good viewing areas, and suggested buffer zones. The DNEF agents would be trained in wildlife inventory and monitoring. They would not primarily act as law enforcement agents.
2. Obtain a serious commitment from the highest levels of the GRM before proceeding, including signing CITES (to insure protection of the chimpanzee), willingness to modify hunting codes, and guaranteed salaries to DNEF agents.
3. Locate a special study area for a long-term research station and perhaps the park's headquarters.

PHASE II. (two years)

1. Define boundaries and classify area as a National Park.
2. Begin access and use limit agreements between DNEF and local populations (including Bozo fishermen).
3. Work within Guinea and Mauritania to prevent abuse of wildlife by non-nationals.
4. Establish permanent DNEF presence and, if possible, start a primate research station as well as park headquarters. Train DNEF technicians in public relations, revised hunting codes and park management.
5. Work on park plan (roads, docks, tourist infrastructure, reservoir management, buffer zones).

PHASE III.

1. Fund infrastructure.
2. Move or condense villages, if necessary.
3. Sign access and use agreements with outsiders, administration and local residents.



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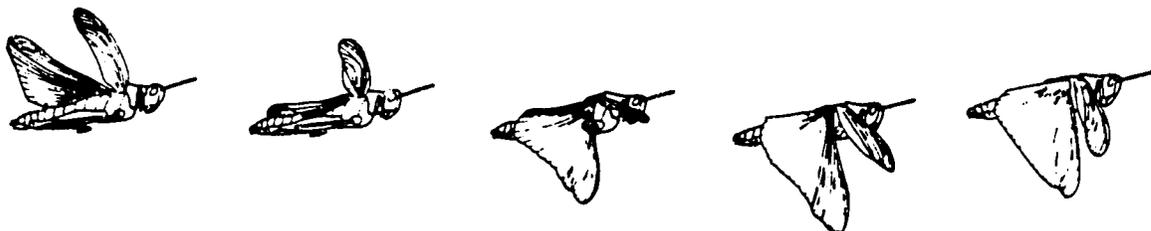
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