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AGRICULTURAL TRADE POLICY REFORM PROGRAM: DESIGN OF AN ENVIRONMENTAL MONITORING SYSTEM

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TABLE OF CONTENTS

		Page
LIST OF ACRONYMS		i
EXECUTIVE SUMMARY		iii
SECTION I	INTRODUCTION	I-1
	A. Description of ATPRP	I-1
	B. Monitoring the Environmental Impacts of ATPRP Reforms	I-2
	C. Why monitor?	I-3
	C1. Overview	I-4
SECTION II	THE NATURAL RESOURCES MANAGEMENT INDICATORS FRAMEWORK	II-1
	A. The Framework	II-1
	B. Application of the NRM Indicators Framework to ATPRP	II-2
SECTION III	IMPACTS OF ATPRP REFORMS	III-1
	A. Will Policy Reforms Occur?	III-1
	B. How Will Policy Reforms Affect Agricultural Output?	III-1
	C. How Will Increased Output Affect the Environment?	III-5
	C1. Cultivation of New Land and Shortened Fallows	III-5
	C2. Increased Use of Agrochemicals	III-5
	C3. Increased Income	III-6
	D. How Will Tariff Reforms Affect Truck Use?	III-6
	E. How Will Increased Trucking Affect the Environment?	III-7
SECTION IV	STRATEGIES FOR ADDRESSING MONITORING AND MITIGATION	IV-1
	A. Conventional Ecological Monitoring	IV-1
	A1. Land Use/Land Cover	IV-1
	A2. Water Quality	IV-2
	A3. Wildlife Populations	IV-2
	B. Monitoring	IV-2
	B1. Conventional Monitoring Systems	IV-2
	B2. Targeted Monitoring	IV-3

TABLE OF CONTENTS
(continued)

		Page
	C. Mitigation	IV-4
	D. Multi-step Monitoring	IV-6
	E. Long-term Monitoring	IV-8
	F. Conclusion	IV-9
SECTION V	MULTI-STEP MONITORING PLAN	V-1
	A. Linking Impact and Environmental Monitoring	V-1
	B. Timing the Monitoring Activity	V-1
	C. Step 1: The Statistical Survey	V-2
	D. Step 2: Impacts of Agricultural Expansion on Vegetation and Habitat	V-4
	D1. Expanding Cultivation and Shortened Fallows	V-5
	D2. Increased Use of Inputs	V-8
	E. Step 3: Impacts of Pollution or Habitat Degradation on Wildlife	V-9
	E1. Pollution	V-9
	E2. Habitat Degradation	V-11
	F. Monitoring Schedule	V-11
	G. Institutional Structure and Staffing	V-12
	H. Cost Estimates	V-14
SECTION VI	CONCLUSION: IMPLICATIONS FOR AID	VI-1
	A. The Problem	VI-1
	B. Monitoring—What For and How Much?	VI-1
	C. Mitigation—To What End, and At What Cost?	VI-2
	D. Timing	VI-3
	E. Conclusion	VI-3
	BIBLIOGRAPHY	VI-4
ANNEX A	AGRICULTURE AND SOILS	A-1
ANNEX B	RANGELAND RESOURCES	B-1
ANNEX C	FOREST RESOURCES IN CHAD	C-1
ANNEX D	WATER	D-1
ANNEX E	WILDLIFE CONSIDERATIONS	E-1
ANNEX F	PERSONS CONTACTED; SCOPE OF WORK	F-1

LIST OF ACRONYMS

AID	(U.S.) Agency for International Development
ASECNA	Agence pour la Sécurité de la Navigation en Afrique et à Madagascar
ATPRP	Agricultural Trade Policy Reform Program/Project
B.E.T.	Bourkou-Ennedi-Tibesti
CAR	Central African Republic
CBLT	Commission du Bassin du Lac Tchad
CIRAD	Centre International de Recherche sur l'Agriculture et le Développement
CTA/PDLCD	Cellule Technique d'Appui à la Mise en Oeuvre du Plan Directeur de Lutte Contre la Désertification
DESV	Direction de l'Elevage et des Services Vétérinaires
DFA	Development Fund for Africa
DREM	Direction des Ressources en Eau et de la Météorologie
EC	European Community
FAC	Fonds d'Aide et de Coopération
FED	Fonds Européen de Développement
FEWS	Famine Early Warning System
GIS	geographic information system
GOC	Government of Chad
GPS	global positioning system
ICBP	International Council for Bird Preservation
IPM	integrated pest management
IRCT	Institut de Recherche sur le Coton et le Textile
IUCN	International Union for the Conservation of Nature
LCBC	Lake Chad Basin Commission
MMERE	Ministère des Mines, de l'Energie, et des Ressources en Eau
NASA	National Aeronautics and Space Administration
NGO	non-governmental organization
NPA	non-project assistance
NRM	natural resources management
OAU	Organization for African Unity
ONDR	Office National de Développement Rural
ORSTOM	Organisation de Recherche Scientifique et Technique en Outre-Mer
PAAD	Program Assistance Approval Document
PASET	Projet d'Appui au Secteur d'Equipements et des Transports
PVO	private voluntary organization
PVO/DIP	Private Voluntary Organization/Development Initiatives Program
RRR	rapid rural reconnaissance
UDEAC	Union Douanière des Etats de l'Afrique Centrale
UNEP	United Nations Environment Program
UNSO	United Nations Sudano-Sahelian Office

USAID	United States Agency for International Development
USDA	United States Department of Agriculture
VT	village territory

EXECUTIVE SUMMARY

The Agricultural Trade Policy Reform Program (ATPRP) is designed to increase the efficiency of Chad's agricultural marketing system for non-industrial crops, by encouraging tariff and regulatory reforms and by helping traders and farmers take advantage of resulting economic opportunities. The reforms focus on several areas:

- Reduction of import duties on agricultural inputs, trucks, and spare parts within UDEAC, the regional customs union
- Elimination of export duties on agricultural production, including those imposed by prefectures
- Liberalization of export licensing procedures for agricultural products

Linked to this program is an effort to track the environmental impacts of ATPRP reforms, which forms the subject of this report and its annexes.

Monitoring the environmental effects of a set of policy reforms is not an easy task, even when reliable time-series data on the economy and the natural environment are available. Moreover, ATPRP reforms have been proposed as part of a package of interventions, including road construction, direct project support for agricultural marketing, etc. These interventions are complementary, so it may not be possible to identify the impact of each one separately.

The general approach we take in this report is to identify a series of causal links through which ATPRP reforms may affect the environment.

First, the tariff and regulatory reforms are expected to stimulate agricultural production, either through extensification onto currently uncultivated land, through shortening fallow cycles on cultivated land, or through introducing chemical fertilizers and pesticides.

Second, extensification onto uncultivated land and shortened fallow cycles can destroy or degrade natural vegetation. Chemical fertilizers and pesticides will enter the water table, the rivers, and critical lakes such as Lake Chad.

Third, degraded vegetation will reduce wildlife habitat and populations. Water pollution could lead to environmental harm through several mechanisms: direct poisoning of animals or humans, poisoning of species low in the food chain reducing the food supply to other species, excess fertilizer creating algal blooms that eventually decrease oxygen supply available to other aquatic species, and so on. The ecological systems of these lakes

are delicate and poorly understood, so we can only roughly approximate the precise impacts of increased agrochemical use.

In addition to the impacts on agriculture, liberalizing truck imports should lower trucking costs, which would lower the cost of fuelwood and potentially result in more rapid forest degradation around urban areas.

The report considers five different strategies for monitoring or mitigating these effects. One is conventional ecological monitoring—simply tracking trends in the environment over time—its major drawback is that it does not establish a relationship between changes in the environment and ATPRP policy reforms. A second strategy is targeted monitoring—tracking the villages and farmers most likely to be affected by ATPRP reforms. This approach addresses the causal link, but does not show the magnitude of the impacts. A third strategy is simply to mitigate environmental harms without attempting to monitor them, the logic being that it is difficult and costly to show actual impacts, so resources are better spent on direct prevention or mitigation. This strategy, however, raises a wide range of questions about what mitigation is intended to accomplish and how mitigation activities could be designed. The fourth strategy breaks the monitoring effort into three independent, simultaneous steps, each corresponding to one link in the causal chain between ATPRP policy reforms and the environment. This has the advantage of making it possible to establish a causal connection between ATPRP and the environment, even though that impact will not actually occur until well after the life of the project. The fifth strategy is similar to the fourth, but stretches the monitoring out over a 10-15 years, making it possible to observe verifiable ATPRP impacts; however, this approach is not feasible within standard AID project cycles.

From a scientific standpoint, the fifth strategy would be the best for monitoring ATPRP impacts; however, because of the length of time involved, the team recommends the fourth approach, multi-step monitoring, as a second-best option. The monitoring would proceed in three steps:

- First, the link between policy reform and agriculture is examined through a statistical survey of farmers designed to determine the extent to which agrochemical use increases or land use intensifies, and to attribute those changes to a variety of possible causes (including ATPRP reforms). This survey would be conducted once, about three years after the tariff reforms go into effect.

- Second, field data collection, aerial videos, and farmer interviews are conducted to calculate the impact of increased input use and intensified land use on vegetation and water quality. This aspect of the monitoring can begin at once, rather than waiting for the reforms to take effect, since the impact of increased agricultural output on the environment will be the same no matter what the ultimate cause.

- Third, field data collection is used to monitor the effects of habitat degradation and water pollution on wildlife populations.

Rough estimates of the direct costs of this effort suggest that the statistical survey would cost about $65,000, and the field work about $100,000 in the first year and $50,000 per year thereafter.

This report also raises a number of general questions about environmental monitoring and mitigation, which should be addressed at both the mission and the agency level:

- What is the extent of the agency's legal requirement to mitigate environmental harm under the terms of the DFA?

- What is to be accomplished by monitoring? Is it necessary to *demonstrate* causal relationships between specific policy reforms and environmental degradation, or is it enough simply to explain how a mission's overall program *could* affect environmental quality?

- What is mitigation intended to accomplish—to prevent harm from occurring, to correct specific identifiable harms, or simply to improve the environment in general? How much mitigation is sufficient, and what should be the relationship among the size of a mission's portfolio, the extent of harm done to the environment, and the resources devoted to mitigation?

- Finally, can environmental monitoring and mitigation be conducted satisfactorily within the five-year time framework typical of AID projects?

These questions go far beyond USAID/Chad and the impacts of ATPRP reforms, and should be raised throughout the agency to arrive at a better-defined strategy for dealing with the environment.

The principal annexes to this report discuss specific sectors of the environment in greater detail, the possible impacts of ATPRP policy reforms, how they could be monitored, and how they might be mitigated:

- Annex A, agriculture and soils, presents an overview of the regions likely to be affected by ATPRP, and lays out a detailed monitoring plan rooted in an understanding of indigenous land management systems.

- Annex B, rangeland resources, covers expected impacts and monitoring, and presents a description of the vegetation of the region based on the team's travels in the field.

- Annex C, forest resources, focuses in particular on village management strategies, and suggests how they can be used to mitigate expected impacts of ATPRP.

- Annex D, water resources, considers dynamic hydrologic systems, water supply and quality, and the influence of ATPRP in the short- and long-term.

- Annex E, wildlife considerations, gives a detailed description of Chad's wildlife resources and habitats, based on field work during this trip, other field experience of the authors, and extensive research of related literature. In addition to discussing key impacts of ATPRP reforms, their monitoring, and their mitigation, it includes a suggested list of threatened and endangered species in the country.

MAIN REPORT

AGRICULTURAL TRADE POLICY REFORM PROGRAM: DESIGN OF AN ENVIRONMENTAL MONITORING SYSTEM

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SECTION I

INTRODUCTION

SECTION I
INTRODUCTION

A. Description of ATPRP

The Agricultural Trade Policy Reform Program (ATPRP) is designed to increase the efficiency of the agricultural marketing system for non-industrial crops. It has two basic components; non-project assistance and project assistance. The first, non-project assistance (NPA), consists of budgetary support in the amount of $9 million to the Government of Chad (GOC) linked to GOC efforts to negotiate the following policy reforms within the Union Douanière des Etats de l'Afrique Centrale (UDEAC):[1]

- reduction of import duties on agricultural inputs, tools, and equipment, and
- reduction of import duties on light and heavy trucks and spare parts for trucks.

In addition, the ATPRP seeks unilateral GOC policy reform to:

- eliminate export duties on agricultural production, including those imposed by the prefectures on goods transported across prefectoral boundaries, and
- liberalize export licensing procedures for agricultural products.

The direct objective of these four reforms is to improve the policy environment for formal sector businesses to participate in agricultural marketing. This is expected to have the effect of lowering the cost of Chadian agricultural produce, making it more competitive on regional markets, and thus stimulating increased production.

The second major component of ATPRP is project assistance. The project is comprised of two sub-components designed to complement and reinforce the policy reforms listed above. The first is an export marketing sub-component, which will provide an advisor to help private businesses on subjects related to export marketing, oversee a number of short-term studies and consultancies, and advise the GOC on policies and programs to develop agricultural exports. The advisor will also assist targeted traders and farmers to locate new export markets and commercial opportunities and take advantage of the economic opportunities created by these policy reforms.

The second sub-component of the project includes policy studies to support the implementation of ATPRP policy reforms and impact monitoring to help the GOC and AID

[1] This report is based on the information about ATPRP reforms which is in the PAAD and its annexes. It does not reflect changes to those proposals which occurred in subsequent UDEAC negotiations, because the team was not informed of those changes until the end of its mission.

understand how NPA interventions affect the people of the Chad. The impact monitoring will begin in the second year of the project and continue through its sixth year, one year after the planned departure of technical assistance personnel. Certain elements of this monitoring will be of importance to this report.[2] In particular, it is to include in-depth interviews with a small number of traders and farmers expected to be most affected by the reforms, and rapid rural reconnaissance surveys of a broader group of traders and farmers to determine the extent of applicability of the detailed data. Linked to this program is an effort to track the environmental impacts of ATPRP reforms; this is the subject of this report, and is discussed in the section which follows.

B. Monitoring the Environmental Impacts of ATPRP Reforms

Monitoring the environmental impacts of ATPRP reforms is conceptually distinct from the overall monitoring activity. The latter is focused on the effects of tariff reforms on their direct objective, agricultural marketing. We will henceforth refer to that activity as "impact monitoring." In contrast, environmental monitoring, which we will refer to as such, is designed to identify unintended negative impacts on the environment attributable to the ATPRP reforms. ATPRP is not an environmental program, and USAID/Chad has not placed the environment among its target areas. This monitoring effort is therefore not designed to track broad evolution of the Chadian environment. Rather, it is focused specifically on the impacts of ATPRP reforms. To the extent that this purpose involves building broad-brush baseline or trend data, that will be done; but the monitoring program is not designed to take on the Chadian environment as a whole beyond the anticipated impacts of ATPRP reforms.

Monitoring the environmental impacts of a set of policy reforms is not an easy task. Even in a country graced with political stability, economic well-being, and detailed, reliable time-series data on the natural environment, it would be difficult to establish a clear causal link between economic policy and environmental quality. In Chad, which boasts none of these assets, it may be impossible. The difficulty lies in the complexity of the web of interactions through which tariffs and agricultural marketing regulations affect economic (in this case primarily agricultural) activity, and through which agricultural activity then affects the environment. While conceptually it is possible to describe that web, the functional relationships between inputs and outputs are too complex to show definitively that a single specifiable input is the one which actually caused an observed change in the environment.

This problem becomes even more difficult when one bears in mind that ATPRP reforms are expected to influence agricultural output only if they are implemented as part of a set of complementary interventions into Chad's agricultural marketing system. Other elements in this combined effort include extensive road upgrading and maintenance (now underway through the multi-donor PASET project), support to improve the productivity and strengthen the market orientation of Chadian farmers (including USAID's PVO/DIP), and assistance in identifying and developing export markets. Each of these interventions is designed to remove a major bottleneck to agricultural expansion. If only one were

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[2] This discussion only touches on the aspects of the impact monitoring plan relevant to environmental monitoring. For a complete description, see Annex F of the PAAD, "Impact Monitoring and Evaluation Plan."

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implemented, output would still be constrained by the other bottlenecks, but if they all occur together, they will complement each other, and agricultural output should be free to increase. Thus the marginal impact on output of any one of the interventions, holding all else equal, is expected to be zero. This is explained in the PAAD agricultural marketing system constraints analysis, which states that none of the ATPRP reforms are expected to affect output in the face of the other constraints at work.[3] In combination, however, the whole set of interventions is expected to have a significant impact on agricultural output. Thus the whole is greater than the sum of its parts; individually, each intervention has no effect, but combined they can lead to growth of agricultural outputs and incomes.

Consequently, the evaluation of the impact of ATPRP reforms on either agricultural output or the environment becomes conceptually, as well as practically, difficult. If no growth in output occurs following ATPRP reforms, one may expect to find that some of the complementary interventions did not occur, and that other impediments continued to limit agricultural production. However, if growth in output does occur and all of the interventions were carried out, it will be impossible to pinpoint causality, since the working hypothesis is that all of the interventions contributed jointly to the growth in output. In this case we will know only that the removal of a set of constraints led to increased output and possibly environmental degradation, but not the marginal impact of each individual intervention.

C. Why monitor?

In view of these difficulties, what can one hope to accomplish by monitoring the environmental impacts of ATPRP reforms? This question is worth addressing, because a better sense of how monitoring information will be used will make it easier to design a system that actually responds to those needs.

One purpose of ATPRP environmental monitoring is to identify areas of negative environmental impact (if any), so that appropriate mitigative action can be taken to the extent possible. To identify areas of negative impact, one must have a way to establish a causal link between the policy reforms and observed changes in the environment. Moreover, it must be possible to determine *how much* of the change in the environment is due to these reforms. The natural environment is already degrading in response to a wide range of factors other than tariff reforms—population growth, drought, cultivator-herder conflict, and political unrest. If, in the next few years, USAID-sponsored policy reforms account for a significant proportion of the degradation, then a case may be made that USAID has some responsibility for mitigating those impacts. If, however, the impact of policy reforms on the environment is trivial relative to the other factors, then USAID may legitimately decline to invest in mitigation, since it has not caused the problem.

When it comes to designing mitigations, the question will arise as to whether mitigation is possible, or the extent to which it is possible, within realistic management and budget constraints. USAID/Chad could find itself required to launch a major environmental effort simply to mitigate the effects of economic reforms, even though it has explicitly

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[3] See PAAD Annex D, "The Agricultural Marketing System Constraints Analysis," pp. 37-42.

decided not to give the environment a prominent position in the allocation of its limited resources. This issue goes far beyond ATPRP policy reforms and the Chad mission, and should be of concern throughout USAID as the agency seeks a balance between economic development strategies and the environment. NPA has been encouraged within the agency in part because it was expected to reduce management costs. However, if the missions are fully to confront NPA's possible environmental impacts, it could turn out to be both more management-intensive and more costly than conventional projects.

A second purpose for monitoring is to learn as much as possible about the mechanisms through which economic reforms affect the environment. This may provide a basis on which to minimize environmental damage in the design of future economic reforms. This issue also exceeds the scope of ATPRP, and it has broad implications for other donor agencies as well as for USAID. A better understanding of economy-environment relations may improve the design of regulatory and tariff reforms, structural adjustment programs, and other policy reform activities encouraged by donor agencies.

C1. Overview

This report is an attempt to grapple with these issues in the context of ATPRP reforms in Chad. It does so in several steps. The following section describes a conceptual framework developed by USAID's Africa Bureau for examining the impact of policy change on resource-based incomes. Although designed to meet a need slightly different from that of ATPRP environmental monitoring, it is nevertheless a useful tool for structuring an approach in the present context.

The third chapter discusses the expected impacts of ATPRP reforms on Chadian agriculture, transportation, and the environment. It considers the extent to which increases in production might come through intensification or extensification of agriculture, and which crops might be produced. This has significant implications for the anticipated environmental impacts.

The fourth chapter considers five different strategies for handling the monitoring and mitigation of ATPRP impacts on the environment. The arguments for and against each strategy are presented, so that the Chad mission will be better equipped to understand the team's recommendations and to make its own choice among the options.

The fifth chapter then considers in greater detail the approach recommended by the team, a multi-step strategy for establishing separately each of the causal links connecting ATPRP reforms to the environment. It considers what data will have to be collected and on what time schedule, the link between impact and environmental monitoring, and possible staffing requirements for the monitoring effort.

The five annexes to this report consider in greater detail the implications of the ATPRP policy reforms for specific elements of the environment: agronomy and soils, rangeland, forests, water, and wildlife. Each makes detailed recommendations concerning monitoring or mitigation of environmental degradation. The recommendations in the main

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body of this report represent a compromise among these detailed suggestions agreed upon by the team members. Because the annexes were written independently, and because there is naturally some overlap among elements of the environment, the annexes may not always agree with each other or with the main report. Their recommendations are naturally more comprehensive than the compromise plan presented in the main report.

5'

SECTION II

THE NATURAL RESOURCES MANAGEMENT INDICATORS FRAMEWORK

SECTION II
THE NATURAL RESOURCES MANAGEMENT INDICATORS FRAMEWORK

A. The Framework

The Africa Bureau's Office of Analysis, Research and Technical Support (ARTS) has developed a framework to relate environmental projects to development objectives.[1] Termed the natural resources management (NRM) indicators framework, it was designed to meet the reporting requirements of AID's Development Fund for Africa (DFA). It provides a structure to show the link between NRM projects and strategic objective 3.1 of the DFA—increases in natural resource-based incomes. The framework sets out a five-level chain of causal linkages between broad institutional or policy reforms, NRM projects, and resource-based incomes. In simplified form, the five steps are as follows (note that the causality flows from the bottom to the top):

Level V	Overall goal - strategic objective 3.1—increase resource-based income and productivity
Level IV	Natural resource base impacts—changes in the resource base as a result of new practices used.
Level III	Adoption of more sustainable or income-generating practices by local farmers and herders.
Level II	Changing institutional conditions which encourage adoption of new practices—planning, policy, management & administration, economic incentives, communications, technology, education, values.
Level I	Activities which bring about changes in level II conditions—encourage better policy making, better management, provide TA, promote participatory processes. Inputs include financial support, TA, studies, commodities, operation and maintenance services, etc.

This framework was designed because bureau staff perceived the difficulty of clearly showing how policy- or institution-oriented NRM projects might actually have an impact on resource-based incomes. Most projects intervene at only one or two levels of this framework, and even with detailed monitoring, it would be very difficult to establish a clear causal relationship between project inputs and rural incomes. This framework allows the design or evaluation team to describe the expected relationships, and to be explicit about which causal links can be shown and which must be assumed to exist.

[1] For more detail on the NRM framework, see Weber, 1991.

For example, a land tenure reform project would involve level I inputs and activities, designed to change the institutional context in which land use and management decisions are made by farmers and herders. It may be possible to show that the level I inputs led to clear changes in level II conditions during the life of the project. Conceivably it might be possible to show level III adoption of new practices by selected local groups. The further impact on the resource base (level IV) and rural incomes (level V) would not be demonstrable during the life of the project.

However, if a second project intervened at level III, it might be possible to show in that case how the use of new management practices led to different resource management strategies (level IV) and thus increased incomes (level V). This would make a more convincing case for arguing that the first project would, in fact, lead to increased income, even though the full chain of causal links could not be shown with respect to a single project. *This principle of decoupling the different links in a chain of causal relations is a powerful tool for evaluating the impacts of complex projects, and will be applied in the analysis of ATPRP impacts on the environment.*

B. Application of the NRM Indicators Framework to ATPRP

The overall objective of ATPRP is to increase agricultural outputs through a set of policy reforms. Although it is not an NRM project, the framework is nonetheless helpful in thinking about its expected impacts. The link between the two components of ATPRP and the indicators framework is shown in the table below:

Level V	Increase farmer incomes through increases in marketed agricultural production	
Level IV	Farm land used differently (impacts environment)	Roads and trucks used more (impacts environment)
Level III	Producers grow more and use more inputs	Traders buy more, export more, use more or better trucks
Level II	Lower or no tariffs (leads to increased demand)	Better knowledge about markets available to traders & producers
Lev.I acts	- Reduced international import tariffs on trucks - Reduced international import tariffs on agricultural inputs - Reduced international export tariffs on agricultural production - Reduced domestic (inter-prefectoral) tariffs on agricultural production - Liberalized international export licensing procedures	
Lev.I input	$9 million to Ministry of Agriculture	$7 million in TA and studies

The ATPRP impact and environmental monitoring will focus conceptually on three steps in this framework. First, the impact monitoring will look at whether the policy reforms have actually occurred at levels I and II of the framework. If they occur, the second question will concern their impact on agricultural output and transportation, the link between level II and levels III and IV. If level III and IV changes in agriculture or transportation occur, then the third issue will be how they affect environmental quality or lead to degradation of the natural resource base. The actual harm to environmental quality or the resource base does not have a place in the framework, but it will flow from level IV of the table.

This report should properly be concerned with only the third step in this causal chain, leaving the first two to the impact monitoring. However, the environmental impacts anticipated from ATPRP reforms depend to a large extent on the mechanisms through which those reforms affect agriculture. To design a monitoring system which could capture information about the anticipated environmental harm, the team unavoidably had to devote considerable attention to assessing how ATPRP reforms could affect Chadian agriculture. To a large extent, the significant variables in the design of the monitoring system are determined by the ways in which agriculture changes, not by the ways in which those changes affect the environment. Moreover, in order to assess the significance of ATPRP environmental impact, it is essential to know how much of the observed environmental degradation can be attributed to ATPRP reforms rather than to other causes. This question necessarily falls within the purview of impact rather than environmental monitoring. Therefore, the team had to address questions about both kinds of monitoring.

9

SECTION III

IMPACTS OF ATPRP REFORMS

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IMPACTS OF ATPRP REFORMS

The mechanisms through which ATPRP reforms could directly affect agricultural production and indirectly affect the environment are fairly complex. In order to know what to look for, the team started with a broad picture of the kinds of impacts that might be anticipated, based on the PAAD and its own expertise. With this general view of possible impacts in mind, the team used the field work to develop a sense of which are of most concern, and so to determine where monitoring may be needed.

A. Will Policy Reforms Occur?

The first major question in looking at the chain of causality linking ATPRP to the environment is whether the policy reforms will actually occur. This is an open question. As the PAAD describes in some detail, implementation of most of these reforms is not under the control of the Chadian government. Import duties on agricultural inputs and transport equipment are set by the Central African States' Customs Union (UDEAC, the Union Douanière des Etats de l'Afrique Centrale), of which Chad is a member. While Chad can work within UDEAC for lowering tariffs in compliance with the ATPRP conditions precedent, it cannot unilaterally reduce them itself. According to USAID/Chad staff, tariff reductions were agreed to at the most recent UDEAC meeting, but it remains to be seen whether they will be ratified. Export duties on agricultural produce are under direct Chadian government control, so there is more hope that they may be reduced in order to fulfill ATPRP conditions. The reduction of prefectoral duties also poses problems. The national government can issue instructions to the prefects to put an end to such taxes, but as a practical matter it does not have the power to enforce such edicts. Above and beyond the prefectoral taxes, road blocks set up by soldiers, local authorities, customs agents, and others impose increased costs on those who would transport agricultural produce within the country. The national government would be hard pressed to stop this practice in the current political climate.

While all of these factors make the implementation of ATPRP policy reforms questionable at best, for the purposes of this report one must assume that they will occur. Clearly if they do not, it is pointless to monitor their impacts on either agricultural output or the environment. It is assumed that in such a case the project component of ATPRP will be modified accordingly.

B. How Will Policy Reforms Affect Agricultural Output?

The PAAD and its annexes consider in some detail the question of whether agricultural output will be affected by policy reforms, and if so how and where. The basic assumption is that ATPRP reforms will stimulate production for export markets, since both reduced export duties and reduced transport costs would make Chadian produce more

competitive in regional markets, particularly Nigeria. This is expected to occur at least in part through agricultural intensification in response to the reduced import duties on agricultural inputs.

The PAAD assumes that markets exist for Chadian produce in Nigeria and elsewhere in the region, and that the impacts of ATPRP reforms will be felt most strongly in the regions of the country which now export agricultural output or which are closest (in travel time) to the border. This means that the impacts should be felt in the southwestern provinces (Logone Occidental and Oriental, Mayo Kebbi, and Moyen Chari) well-served by road to Cameroon and Nigeria, and in the areas of the Ouaddaï which already export vegetables to Nigeria. The PAAD also anticipates impacts in the Kanem and Lac provinces (see Map 1 on the following page). The team did not visit those regions because of political unrest, which may also keep the activities of the export marketing advisor from reaching those areas, reducing the impacts of the reforms north of Lake Chad at least in the short term.[1]

While accepting these general assumptions, the team devoted considerable attention to two particular issues raised in the PAAD which will have significant implications for the environment. One is whether increases in output will come from intensification or extensification of agriculture. The other, related to the first, concerns which crops will be grown if an increase in output results from ATPRP reforms.

On the issue of intensification versus extensification, the team expected to see largely extensification, except for a few special cases. This conclusion was prompted by a variety of reasons. First, it is usually less costly to increase production by expanding traditional farming techniques on uncultivated fields than by introducing new purchased inputs such as fertilizers or pesticides. In most of the areas visited by the team, interviews with the farmers suggested that land was not a constraint on agricultural expansion (although in specific areas around Moundou it clearly is a major limitation). The relatively recent introduction of animal traction has increased the amount of land which can be cultivated by one person, but for the foreseeable future sufficient land should be available in most of the areas visited.

Second, the availability of cash with which to purchase inputs would limit development of a commercial market for agrochemicals. At present chemical fertilizers and pesticides are supplied by CotonTchad for use in the production of cotton, as part of an integrated package which includes seeds, inputs, instructions on their use, and credit for their purchase.[2] Many farmers expressed interest in applying agrochemicals to crops other than

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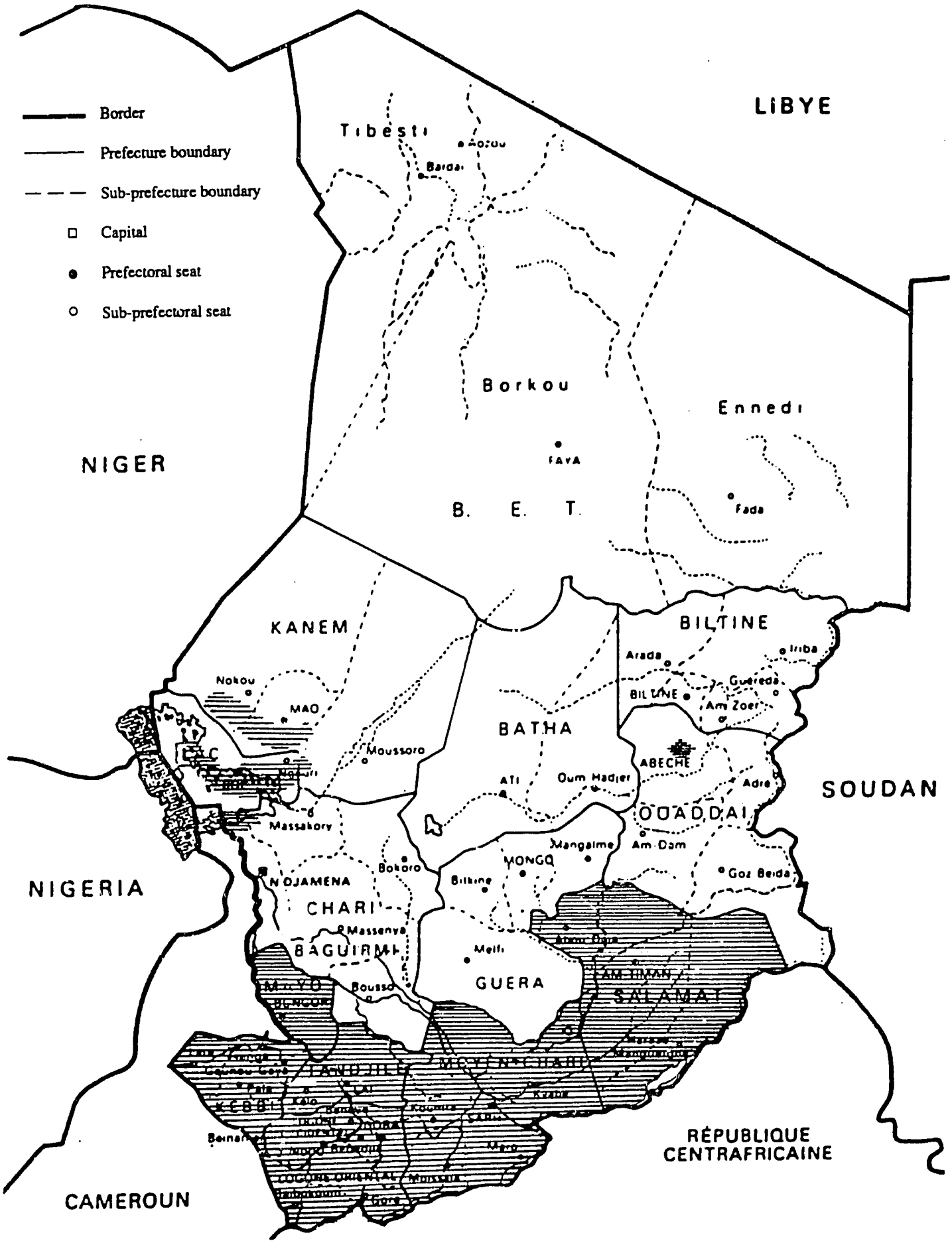
[1] USAID staff suggest, based on recent visits to the Salamat, that ATPRP impacts may also be felt in that province. Because the Salamat was not one of the regions singled out in the PAAD, the team did not visit it, and it has not been specifically addressed by this report. However, the monitoring recommended herein could easily be extended to that region if considered advisable.

[2] All of the peasants interviewed said that they received their inputs from the Office National de Développement Rural, ONDR. The ONDR offices in both N'Djaména and Moundou said that in fact ONDR does *not* supply any agricultural inputs, and the peasants were receiving these products from CotonTchad. Prior to 1986, such inputs were supplied by ONDR agricultural extension agents, so possibly the peasants have confused the two agencies and think that they are the same.

Map 1: ATPRP Impact Target Areas



cotton. However, they uniformly said that they would not be able to buy them even if they were available in the market, because they have no cash at the start of the agricultural season and no credit would be available from commercial vendors. Thus any businessman interested in setting up a sales and distribution network for agrochemicals would also have to go into the banking business. So far no one has done this, and with both political and physical climates as uncertain as Chad's, it may not prove a good investment for some time.

Knowledge about agrochemicals might also limit the development of a commercial market, at least in the short run. A number of farmers said that although pesticides would help them considerably in production of other crops, these were dangerous poisons that they wouldn't purchase directly because they wouldn't know how to use them. Unfortunately, such caution would probably be quickly put aside if the products were readily available.

For all of these reasons, the team concluded that although there is considerable potential for increased agricultural output through use of agrochemicals, their use outside of donor-funded projects is likely to remain relatively limited even if they can be imported more easily.

The team's travels in the field helped develop a clearer sense of which crops are likely to be produced if farmers expand output. Recessional agriculture on river and lake flood plains and in the wadis shows much potential for increase. The most common flood plain commodities are rice, sorghum, maize, tomatoes, garlic, and onions. Of these, rainy season rice, in particular, appears to be a prime target for investment in increased output. It is likely to receive much of the labor (e.g., construction of dikes for water control) and chemical inputs, insofar as they are affordable or credit is supplied by projects. It could moreover become a major source of pollution to Lake Chad.

Other recessional crops are also well suited for agrochemicals. However, they are likely to present less risk of water pollution. The long period between pesticide application and the next rainfall would allow sufficient time for many (although not all) pesticides to degrade. Farmers are unlikely to fertilize recessional crops, because it is not clear that the investment would pay off. Agronomic research would be needed to determine the benefits of fertilizer for recessional crops before any recommendations could be extended to farmers in this area.

Irrigated agriculture could also become a major source of water pollution. Project-supported gardens and rice paddies are currently the only significant users of agricultural chemicals outside of the CotonTchad system. Vegetables, rice, maize, wheat, cotton, and sugarcane are the crops most likely to receive chemical inputs in the near future. However, the investment required to introduce irrigated cultivation makes it unlikely to increase significantly without project support, so irrigation-generated water pollution is not a matter for imminent concern. Moreover, unlike other agricultural systems, irrigated agriculture leads to point source pollution, which is relatively easy to identify and monitor. If it does turn out to be important, therefore, it will not be difficult to integrate it into the monitoring system at a later date.

C. How Will Increased Output Affect the Environment?

Increases in agricultural output can affect the environment in a variety of ways, both directly and indirectly. The team focused largely on the direct, or primary impacts, because measuring the secondary and tertiary ones will be too difficult and will require a longer time frame than is possible under this project.

C1. Cultivation of New Land and Shortened Fallows

One major source of direct impact on the environment will come from cultivating new land (agricultural extensification) and shortening fallow cycles (one form of intensification). These will directly harm the environment as natural vegetation is lost, and indirectly do so as human and livestock populations place more pressure on the remaining natural vegetation for fodder and fuel. This increased pressure will cause a decrease in the variability of plant species composition and numbers, which will in turn constitute a loss of habitat (food supply and shelter) for animal species. As a result the variability of animal species composition and numbers will also decline. The replacement of diverse plant life with relatively uniform plant life (agriculture) will probably lead to large increases in the numbers of a few animal species which feed off agricultural production, such as locusts, rodents, and red-billed quelea (a bird pest).

Expanded cultivation and shortened fallows will bring under cultivation land less productive than what is now cultivated (assuming that farmers already cultivate the most productive land to which they have access). This less productive land will be more subject to erosion from wind and water than higher-quality land. Moreover, to the extent that remaining vegetation is degraded, the soil in which it grows will have less protection against erosion, compounding the potential for total loss of vegetative cover (and thus desertification).

Increased soil erosion will lead to increased sedimentation of rivers and lakes, which in turn will inhibit growth of aquatic grasses serving as an important source of habitat for aquatic species. This will reduce populations of those species and of the palearctic migratory birds which feed on them.

In certain regions of the country, expansion of agriculture may also directly encroach on the habitat of large mammals, leading to declining mammal populations, both as the animals move in search of other sources of food or shelter, and as poaching increases with more human-animal interaction. This is not likely to be an issue in the geographic regions of where the PAAD anticipates ATPRP impacts, except in Manda National Park. If any impacts are felt in the Salamat, then Zakouma National Park could be affected.

C2. Increased Use of Agrochemicals

Increased use of agrochemicals (chemical fertilizers, herbicides, and other pesticides) will lead to increased quantities of these chemicals in groundwater, rivers, and lakes. Thus agrochemicals may cause harm in a variety of ways:

15

- Animals or humans are directly poisoned by pesticides. This would take a relatively high concentration of chemicals, so it is not expected to be a problem except possibly in the wells of villages with interior circulation of ground water or, of course, in case of accidents in handling.

- Herbicides, insecticides, and other pesticides in the water kill plants and small animals low in the aquatic food chain, eliminating the food supply of animals higher in the food chain. Their numbers go down as they die or seek food elsewhere.

- Fertilizers in the water lead to excessive growth of algae and other plants. Their death and decay uses much of the oxygen in the water, and most other aquatic species can no longer survive in the oxygen-depleted environment.

- Increased use of herbicides is associated with clear farming and destruction of habitats at field edges. This is not expected as a result of ATPRP reforms, because herbicides are not available to kill striga, the major plant pest faced by Chadian farmers.

C3. Increased Income

Beyond its direct harm to the environment, increased agricultural output will increase farmers' incomes, possibly resulting in increased investment in livestock. Increased livestock populations would add to the direct pressure on natural vegetation, with consequent additional harm to wildlife populations. While it might be important, this impact will be too indirect to be able to trace, so the proposed monitoring system does not attempt to do so.

Increased income is also expected to lead to increased population, at least in the short- to medium-term, as farmers would be able to afford medical care, which reduces infant mortality. Increased population will in turn lead to additional pressure on the environment from all sources—cultivation, livestock, fuelwood, etc. This effect will also be too indirect to show through the proposed monitoring system.

D. How Will Tariff Reforms Affect Truck Use?

The reduction of tariffs on the importation of trucks and truck spare parts is of importance to ATPRP goals because it will lower one of the input costs to agricultural marketing; this issue is implicitly incorporated in the discussion above. From an environmental perspective, it may also have impacts through increased air pollution, accidents, gasoline spills, lower cost of fuelwood gathering, and so on. The question of the magnitude of increased truck use is therefore of importance separately from its role as an input into agricultural exports.

The environmental profile team did not include anyone with the expertise in transportation demand analysis required to assess the impact of tariff reductions on truck use, so the team accepted the analysis presented in the agricultural economic annex of the PAAD

16

(Annex C), which in turn is based on analysis done by the World Bank through its roads improvement project.[3] The World Bank estimated the price elasticity of demand for transport at -0.76 (i.e., a 1 percent decrease in price will result in a 0.76 percent increase in consumption). Based on this, they predict an overall 19 percent increase in vehicle miles travelled in response to the ATPRP tariff reforms relative to what the demand would be *if all tariffs were now paid in full.* However, the PAAD analysis assumes that at present only 25 percent of the tariffs are actually paid. Thus the average cost reduction is only 25 percent of the nominal cost reduction due to tariff reforms, and the anticipated demand increase only 4.75 percent rather than 19 percent. This is the figure used to assess the importance of increased truck movement to environmental quality.

E. How Will Increased Trucking Affect the Environment?

The 4.75 percent increase in truck miles travelled predicted by the PAAD could affect the environment in several ways:

- increased air pollution
- increased accidents injuring humans, livestock, or wildlife
- increase risk of toxic spills (gasoline, batteries, etc.)
- decreased cost of trucking leads to expansion of "woodsheds" around urban areas and thus destruction of forests
- decreased cost of trucking as an input into the more competitive position of Chadian agricultural products on regional markets. This indirect effect is addressed by the discussion above on the impacts of increased agricultural output on the environment.

The team considered that first three increases are small enough that they do not pose a significant threat to the environment. This is the case for several reasons. With respect to air pollution, the current level of vehicle use in Chad is so low that it is not a problem even in N'Djaména where vehicles concentrate the most. The importance of a given increase in vehicle emissions depends not only the absolute magnitude of that increase, but on whether the increased emissions will disperse without significant increases in ambient pollutant levels. Given the low level of air pollution in Chad now, this is not a matter for concern. Moreover, by encouraging the purchase of new vehicles, these reforms will actually decrease the pollutant discharge per vehicle, since new vehicles will be designed to meet emissions regulations of western countries, and therefore will be less polluting than those currently driven in Chad. Similarly, with respect to driving accidents and toxic spills, the risk involved is low because of the low level of traffic flow expected even after the tariff reforms go into effect.

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[3] See Annex C of the PAAD, pp. 40-43.

The question of the impact of cheaper trucking on fuelwood consumption and thus on peri-urban forests is more complex, and was the subject of some debate within the team. Essentially the argument is that lower trucking costs will make it cost-effective to bring fuelwood from a larger radius outside of urban areas. Fuelwood traders will either pass on the cost reductions to consumers through a lower cost of fuel, or at the current market price travel further to collect the same quantity of wood, causing less destruction to each forested area. The latter is unlikely, since commercial fuelwood harvesting occurs through clear-cutting rather than selective cutting.

The impact of the former depends on the price elasticity of demand for fuelwood. If demand is price elastic, then a decrease in price should lead to an increase in consumption, with consequent harm to forest resources. If demand is price inelastic, the decrease in price should not make much difference. This will be the case if fuelwood consumption per capita, like consumption of staple foods, is relatively fixed, in which case it would not change with a decrease in price. (It would, of course, rise with population increases, but this is unrelated to ATPRP impacts.) Alternately, demand could be responsive to a decrease in price, as households make less effort to economize in their use of wood. A third possibility is that the total supply of fuelwood is now limited by the lack of trucks to transport more wood, and only the reductions in tariffs will make it possible to increase the supply of transportation. In this case price may not drop, but the supply of wood, and thus forest destruction, will increase as transport becomes available. On balance, the price inelastic position prevailed. Thus the monitoring program does not include a peri-urban forest component.

SECTION IV

STRATEGIES FOR ADDRESSING MONITORING AND MITIGATION

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The complexity of the economic and natural systems make it difficult to design a monitoring system that can establish an unequivocal causal relation between policy reforms and environmental degradation. The team considered a number of quite different approaches to this problem, each of which offers advantages and disadvantages and involves compromise. Each of these approaches is described in this section; the one recommended is considered in more detail in the following section.

A. Conventional Ecological Monitoring

Conventional ecological monitoring concentrates on building time series data on the evolution of the physical and natural environment. Such systems may routinely collect data on water quality, water flows, rainfall, natural vegetation cover and species composition, wildlife populations and migratory behavior, and so on. These data reveal changes over time and establish a baseline for "normal" environmental conditions. Such data also make it possible to flag problems by observing trends or aberrations over time or space.

In the ATPRP context, conventional monitoring would focus on aspects of the environment expected to be affected by ATPRP reforms. This could include several kinds of information:

A1. Land Use/Land Cover

Changes in human use of land through agricultural expansion, deforestation, or urban growth, and the resulting impacts on vegetation and soil erosion, are a fundamental building block in any information system on the natural environment. A number of land use/land cover maps have been developed for specific regions of Chad in the past few years. However, each of them covers only part of the country, usually one or two provinces. Because they were funded by different donors, they use different classification schemes, so the data are not compatible from one map to another. Moreover, each was a one-time effort with no updates planned. Therefore, while they are of interest to people concerned with the provinces they cover, they cannot be used to monitor change over time.

Since one major effect of ATPRP on the environment is expected to be habitat loss due to agricultural extensification, the development of a system to monitor changes in land use and land cover might be an appropriate response. Such a system would probably involve an areal sampling frame approach to tracking changes in land use and vegetative cover over time. Data would come from satellite images or aerial photographs, depending on the resolution required, combined with ground truthing to facilitate image interpretation. The monitoring system would have to be institutionalized within the Chadian government, so that

20

there would be some hope of it becoming an ongoing activity beyond the life of the ATPRP project.

A2. Water Quality

The increased use of imported agrochemicals that should result from ATPRP reforms is likely to degrade water quality in the Lake Chad and Lake Léré watersheds. In addition, ATPRP-induced expansion of agriculture will lead to cultivation of marginal lands, which in turn will increase soil erosion and the level of suspended solids in the lakes and rivers. The development of a broad water quality monitoring network would make it possible to determine what was entering the watersheds, where, and how this was affecting downstream water quality at different times of the year. Such a system would involve developing a network of technicians who would collect samples, do as much testing as possible at the site, and then forward the samples (or results) to N'Djaména to build a water quality database. It might be possible to link a water quality monitoring system to the hydrological monitoring system now managed by the Direction des Ressources en Eau et de la Météorologie; AGRHYMET support; however this would depend on the extent to which the same data collection points were appropriate for the two kinds of information.

A3. Wildlife Populations

The degradation of habitat and water quality which could result from ATPRP could also lead to decreases in wildlife populations and possibly to direct wildlife kills. A system to monitor wildlife populations and direct wildlife kills would help detect such impacts. Lakes Chad and Fitri will be particularly sensitive areas for wildlife degradation because they host large seasonal populations of palearctic migratory birds, which would be detrimentally affected if their winter habitat were degraded. To the extent that ATPRP impacts are felt in the Salamat, the large mammal populations now in Zakouma National Park may also be victims of ATPRP reforms. The manatees in Lake Léré would warrant monitoring, since it would certainly be affected by ATPRP. Such a system would involve sending teams of wildlife specialists to the targeted sites on a regular basis to do bird, mammal, or fish counts. The results could be expected to lead to more in-depth research projects to determine the causes of observed population changes. This could also be complemented by an effort to improve commercial fishing statistics from the Chari and Logone Rivers, Lake Chad, and possibly other lakes.

B. Monitoring

B1. Conventional Monitoring Systems

While conventional monitoring systems such as these provide valuable background information for examining a variety of environmental issues, they usually do not allow one to say much about the causes of the problems observed. In the ATPRP context, one might observe a decline in manatee populations in Lake Léré, but it would be impossible to attribute this to pesticides provided as a result of ATPRP tariff reductions. Similarly, if there were a decrease in the quality of grazing land outside of Abéché, there would be no

21

way to link it to agricultural expansion in the wadis, much less to trace that expansion to increased Nigerian demand resulting from reduced export duties and transport costs. For this reason, such monitoring has not been carried out in most Sahelian countries. Its cost is high, and it is hard to justify the investment without knowing how the resulting data will answer identifiable environmental management questions. The team rejected conventional ecological monitoring since it would not make it possible to show any relationship between degradation observed and ATPRP tariff reforms.

B2. Targeted Monitoring

A second possible approach focuses specifically on the activities of farmers expected to be the most affected by ATPRP reforms, to determine whether they are noticeably harming the environment. It involves detailed case studies of individual farmers expected to benefit from ATPRP reforms, to determine through interviews whether their economic behavior has changed because of the policy reforms. If they have in fact changed their agricultural practices because of the policy reforms, then environmental monitoring would begin *on those fields* to see what the impact has been on the environment.

In order to find farmers whose practices change *because of ATPRP reforms*, this approach ties environmental monitoring closely to the rest of the ATPRP project component. The export marketing specialist is expected to identify specific traders and farmers best placed to take advantage of the ATPRP reforms. S/he will work with that group to ensure that they have all the information needed to benefit from the new opportunities, thus increasing the probability that they will be affected by lower tariffs. The environmental monitoring team will then target the same individuals. They should fall into three groups:

- those expected to be affected who in fact did not increase production;
- those who increased production but attributed it to other input factors than ATPRP;
- and those who said that ATPRP reforms did in fact make it possible for them to increase output.

The farms of the third group would be monitored for evidence of environmental harm, while those of the first group would be monitored to serve as a control group for comparison purposes.

This approach has two problems. First, while it may show specific examples of environmental harm due to ATPRP reforms—presumably the worst cases—it shows nothing about overall magnitude of ATPRP environmental effects or their importance relative to other sources of environmental degradation. If the concern is only with showing whether ATPRP has had *some* impact on the environment, this would suffice. However, without knowing the relative importance of ATPRP-induced environmental degradation, we cannot assess whether USAID should be called upon to mitigate ATPRP impacts.

Second, even if we could identify specific instances of ATPRP-caused environmental harm through targeted monitoring, they are not likely to show up during the life of the project. ATPRP policy reforms are expected to go into effect in 1995 (if at all), and it will be several years before their impact on agricultural output is felt; it will be several more years before expanded agricultural activity is likely to begin harming the environment. The ATPRP project component is scheduled to end in 1998; this will be well before we could reasonably expect to observe ATPRP-caused environmental harm in the field.

For both reasons, the team felt that targeted monitoring alone was insufficient to deal with the environmental impacts of ATPRP reforms.

C. Mitigation

In light of the difficulty in establishing the importance of ATPRP as a source of environmental harm, the team considered a third approach. This is simply to assume that ATPRP will harm the environment and put the available resources into mitigation without establishing the precise nature or magnitude of that harm. Two arguments are used to justify this strategy. One argument is that, although the kinds of harm which may occur can be predicted, they can't be shown, so resources devoted to monitoring will simply be wasted. The second argument is that the only effective way to mitigate ATPRP-generated environmental damage is to prevent the harm from occurring, rather than compensating for it after the resources have been destroyed. Thus, in terms of protecting the Chadian environment, the available resources would be better spent on mitigation than on monitoring.

If this approach were followed, the question arises of how mitigation resources should be used. A number of mitigations to possible ATPRP-generated problems were suggested by team members: projects to introduce agroforestry or soil conservation techniques in targeted areas, support for village land management, pesticide control and education activities, environmental education projects, population control, conservation projects targeted at specific endangered species, and so on. However, for the most part these represented particular interests or concerns of the team members, rather than a broader strategic consideration of what mitigation should be expected to accomplish.

Mitigation could serve a number of different purposes. One approach is to view it as a way to correct specific environmental harms create by the project—the logic behind the "no net loss" standard for evaluating the destruction of wetlands in the United States. According to this principle, developers may destroy existing wetlands if they replace them with comparable ones elsewhere. In order to implement this principle, it is necessary to know exactly what harm has been caused by the project, so as to determine what mitigation actions are appropriate.

Such narrowly targeted mitigation is difficult, for a number of reasons. Without any monitoring, it is impossible to know for sure which ATPRP-caused environmental problems may be the most serious, and what actions are appropriate to correct those problems. Moreover, it may be that the problems caused by a particular project are trivial relative to the overall environment of the country. If so, resources devoted to addressing the specific

project-generated problems might not be a cost-effective way to invest in environmental improvement. For example, although ATPRP might increase air polllution, mitigation would be misguided in the broad context of Chadian environmental problems. In addition, the environmental impacts of policy reforms like ATPRP may be too diffuse to allow for such precise mitigation. Where a project destroys a specific resource or wildlife habitat, it is possible to think in terms of replacing it; but where a set of policy reforms leads to a marginal increase in overall habitat encroachment across a large region, it is not obvious how to replace a specific resource.

A second approach, which addresses some of these difficulties, would be to prioritize the country's overall environmental problems and allocate mitigation resources accordingly. Carrying out such an assessment of environmental mitigation priorities in Chad would require a massive effort comparable to the environmental action plans of the World Bank, the tropical forestry action plans of the FAO, or the desertification control plans of UNSO (United Nations Sudano-Sahelian Office). This was beyond the scope of this report, and did not seem appropriate for USAID/Chad to undertake, especially since the mission has explicitly chosen not to include the environment as one of its areas of focus. Moreover, there already is a desertification control plan, prepared by the Cellule Technique d'Appui à la Mise en Oeuvre du Plan Directeur de Lutte Contre la Désertification (CTA/PDLCD), with funding from UNSO.[1] Through this document the GOC has established its own priorities for environmental work. A round table on the environment is anticipated for May, 1993, at which the primary conclusions of this plan will be presented, along with national priorities for further work in the environmental area. In light of this, it would seem more appropriate for USAID to put its mitigation resources into priority areas identified in this plan rather than defining its own.

A third possible mitigation strategy was suggested in light of the relatively small amount of money available. The team was well aware that the funds reserved for mitigation could easily be consumed simply in designing a mitigation program, without ever carrying it out. Instead, therefore, it was suggested that USAID review the environmental programs currently underway in Chad with funding from other donors. If one is focusing on problems like those created by ATPRP reforms, and appears to be effective and well-managed, the available resources could simply be contributed to extend or expand the work of that project. Candidates which might be considered for such support include the FAO forestry project south of N'Djaména (FAO Project GCP/CHD/020/NET), the upcoming FED project in Zakouma National Park, or the Netherlands/UNDO project that is drafting pesticide legislation for the GOC; there are certainly others as well. The advantages of contributing to an existing activity are that none of the resources would have to go to project design, and mission management time might be kept to a minimum. However, this would require some negotiating with the other donor involved in order to make it workable.

A fourth approach is to design project or program interventions so as to prevent environmental harm from occurring in the first place, rather than to allow the environment to be harmed and then try to correct the damage. This is the rationale behind the village land

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[1] See CTA/LCD, 1990.

management approach to rural development which is being encouraged by the World Bank and other donors in many Sahelian countries. It also underlies the current emphasis on land and tree tenure reform in the Sahel as a way to encourage sustainable land and forest management. This is feasible as a way to approach the design of certain kinds of development projects, but may not be appropriate for all.

Several objections were raised to this mitigation-only approach. One was that it might be possible to establish some causal relationships between ATPRP and environmental degradation, and that even if the results are rough they would be adequate to justify the monitoring effort. Although the Chadian environment might be better off in the short- or medium-term with mitigation than with monitoring, the benefits of showing (or disproving) the link between economic reform and the environment could be felt throughout the Sahel by helping to design better policy reforms in the future. A second objection is that the mitigation approach effectively forces the Chad mission to take on an environmental project of some sort, even though this is explicitly outside the scope of its country strategy. This may turn out to be unavoidable if the mission is adequately to deal with the environmental impacts of macroeconomic policy reforms. However, it is a matter of some concern because it will divert staff energies away from the mission's primary goals in Chad. Determining the extent of ATPRP environmental impacts may help limit the demands placed on the mission for environmental projects.

D. Multi-step Monitoring

A fourth approach is considerably more complex than those already discussed, but offers some promise of being able to show both the particular nature of the harms caused by ATPRP and their importance relative to other sources of environmental harm. It combines village-level data collection in some respects similar to the targeted monitoring discussed above with a statistical survey of farmers, in a several-step strategy designed to establish how much environmental degradation may actually be attributed to ATPRP policy reforms. This approach relies on the principle of decoupling several steps in a causal chain which underlies the NRM indicators framework discusse in Section II above.

Each step in the monitoring system corresponds to one causal link in the conceptual understanding of the connection between tariff policy and the environment:

- Policy reforms trigger increased agricultural production either through increased use of agrochemical inputs or through expanded cultivation and shortened fallows.

- Increased use of inputs leads to decreased water quality and degradation of aquatic habitat; expanded cultivation and shortened fallows lead to degradation of existing vegetation and terrestrial habitat.

- Decreased water quality brings about wildlife deaths from pesticides; habitat degradation (aquatic or terrestrial) leads to decreased wildlife populations as carrying capacity of the environment drops.

Each of these three causal links is investigated through a separate monitoring effort; the three efforts need not be directly linked to each other. The first monitoring step, which affects link 1, is the only one that is particularly related to ATPRP reforms. It involves a broad statistical survey of farmers in the provinces likely to be affected by ATPRP reforms, asking about changes in their agricultural practices and the causes of those changes. The survey is designed to determine the extent to which agrochemical use increases or land use intensifies, and to attribute those changes to a variety of possible causes (including ATPRP reforms). This will be a one-time survey of several hundred farmers, carried out three years after ATPRP reforms go into effect.

The second step, addressing both parts of link 2, is similar to the targeted monitoring discussed above, but it need not be carried out in villages actually affected by ATPRP reforms. It entails visual observation of the environment through field data collection and aerial videos, in order to determine the impact of increased input use and intensified land use on vegetation and water quality. Complementing the visual observation will be in-depth interviews with farmers, which will provide information for interpreting the field data. This part of the monitoring will be carried out annually, beginning as soon as the ATPRP project component gets underway.

While sites chosen for this work *may* be those affected by ATPRP reforms (and in fact probably will be if the impact and environmental monitoring efforts are linked as they should be), they do not *need* to be in order to show a relationship between increased agricultural output and the environment. The impact of agriculture on the environment will be the same irrespective of what led to increased agricultural output. Thus this monitoring can begin immediately, on any village where agriculture is expanding, and need not wait until ATPRP effects on agriculture are felt. In contrast, in the targeted monitoring discussed above, the villages would have to be affected ATPRP before they were chosen, since there would be no statistical survey to establish the first causal link. Therefore the targeted monitoring could not be carried out until ATPRP impacts were identified—after the project had been completed.

The third step which deals with link 3, also involves field observation, and from a management perspective it can be linked to the second step. It includes collecting data on wildlife populations that can be correlated with trends in water pollution and habitat degradation, in support of a causal link between environmental damage and loss of wildlife.

The advantage of this approach is that it should make it possible to establish a causal link between ATPRP policy reforms and environmental degradation. Nevertheless, it contains several disadvantages. First, the reliability of that link depends entirely on the reliability of the statistical survey—how well it is designed, and how much faith one can put in farmers' assessments of the reasons for changes in their agricultural practices. Both of these are open to question. Moreover, there will be no way independently to verify the survey results; one can only look at the questionnaire and make a value judgment as to its suitability to obtain the desired information.

Second, this approach requires USAID/Chad to invest significant resources in field data collection to establish the second causal link, without knowing whether the first one has occurred. If the survey should show that ATPRP reforms had no impact on agricultural production, then the expenditure of those resources will prove to have been unnecessary. While the data obtained might be interesting for other purposes, it may not justify the investment from the perspective of USAID/Chad.

E. Long-term Monitoring

A fifth approach considered by the team is characterized primarily by relaxing the time constraints imposed by the ATPRP project. It envisions a 10-15 year monitoring effort, long enough to observe the environmental impacts of ATPRP reforms. The content of the monitoring would be similar to the multi-step monitoring, but the effort would be spread out over a longer period of time. Thus the statistical survey would be carried out before most of the field data collection, if it showed no impact then further field work would be unnecessary.

The advantages of this approach are clear. With a longer time frame, it would be possible to monitor the different causal links in the order in which they occur, reducing the amount of field data collection required before determining if ATPRP reforms have, in fact, had an impact on agricultural production. If it turned out that ATPRP reforms had not had any impact on production, then there would be no need to continue monitoring, since there would be no environmental impact.

Extending the schedule for monitoring would also make it possible to face a variety of issues not feasible within the shortened time schedule of the multi-step monitoring. In general, with a 10-15 year monitoring program it would be possible to establish baseline data and observe changes in the environment over time. This would not be possible with a shorter program, because too much annual variation results from other causes to be able to pinpoint the impacts of ATPRP-related changes. More specifically, with a longer monitoring program, it would be interesting to gather data on indigenous soil classifications, and how farmers approach their management. Such information can be of great value in understanding the impact of policy reforms on land management in different parts of the country, and thus on the environment. With a longer monitoring schedule it would also be worthwhile to census populations of selected bird and mammal species on the lakes and in specified parks and reserves, since the time series would be long enough to expect meaningful results.

Long-term monitoring has, however, several disadvantages. It would require severing the link between environmental monitoring and the rest of the ATPRP project, increasing the overall management burden on USAID/Chad. It would also saddle the mission with a requirement to monitor ATPRP reforms well into the next decade, beyond the tenure of any current mission staff and beyond the duration of the current country strategy. This might become a significant constraint in the future, limiting the ability of future staff to design their own activities. The changes in mission staff and strategy would also make it difficult to sustain a consistent monitoring effort, even if the same contractor were responsible over the

whole period. More immediately, it would not be possible to link long-term environmental monitoring to ATPRP impact monitoring, thus increasing the cost, since the two activities could not share resources. It would also be considerably more difficult to retain the same personnel throughout the environmental monitoring process, as it would be hard to guarantee the availability of any specific individuals for intermittent work over 10-15 years. Even if long-term monitoring covered the same data as multi-step monitoring, it is likely to be more expensive, if only because of the longer management period and inflation.

F. Conclusion

On the basis of merit alone, the team would recommend that USAID/Chad implement a 10-15 year program to monitor the impacts of ATPRP policy reforms on the environment. However, this seems unrealistic, because it involves changing two basic parameters of the environmental monitoring as described in the PAAD, its schedule and its link to the ATPRP project. For this reason, the team settled on multi-step monitoring as a second-best approach. The next section describes the proposed program in more detail.

SECTION V

MULTI-STEP MONITORING PLAN

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MULTI-STEP MONITORING PLAN

A. Linking Impact and Environmental Monitoring

To be effective, the multi-step environmental monitoring recommended by the team must be integrated with the impact monitoring component of the ATPRP project. The statistical survey that addresses the causal link between ATPRP and the environment is essentially designed to accomplish one major objective of the impact monitoring: to show that ATPRP reforms have had an impact on agricultural activity. However, the survey proposed here goes beyond the rapid rural reconnaissance envisioned by the monitoring plan, since it is designed to collect statistically representative data for making reliable generalizations about a large portion of the country, rather than simply to gather *ad hoc* data not expected to be representative.

This greater rigor is essential for the environmental monitoring to be meaningful. While the impact monitoring is concerned only with showing that tariff reforms *have* affected agriculture (and, of course, other areas of economic activity), the environmental monitoring needs to establish the importance of that impact *relative to other factors* leading to increased agricultural output. This is essential to assess USAID's responsibility for mitigating environmental harm caused by agricultural expansion. The team is therefore recommending significant revisions to the data collection activity proposed in the impact monitoring plan, to make it possible to show a link between ATPRP and the environment.

In the case of the field work, the connection between the environmental monitoring and the impact monitoring will allow the project to take advantage of economies of scale. The impact monitoring plan calls for tracking farmers expected to be affected by ATPRP reforms and carrying out key informant interviews on a regular basis. The environmental monitoring will also call for detailed interviewing of targeted farmers, in conjunction with detailed data collection at the village level. The two efforts should be combined in order to carry out a single set of interviews each year with the same group of farmers. Moreover, these should probably be the same farmers as those targeted by the export marketing specialist, in order to maximize the chances of working with farmers affected by ATPRP reforms.

B. Timing the Monitoring Activity

By breaking the monitoring down into steps, it is possible to come to grips with the time frame allowed for carrying out both impact and environmental monitoring. The ATPRP project is expected to begin in summer or fall 1993, and the policy reforms are expected to go into effect in 1995. The statistical survey of farmers should be carried out three years after the policy reforms go into effect, or around 1998; this allows time for the reforms to filter through to the farmers. One would expect to see environmental impacts beginning to

occur even later than that, once the effects on agriculture have been felt for some time. However, because the life of project will be five years, it will not be possible to monitor environmental impacts that far into the future.

By decoupling the different steps in the causal chain, monitoring for environmental impacts of increased agricultural activity can begin *before* the tariff reforms go into effect. The environmental impacts of increased agriculture will not generally depend on whether those increases are due to ATPRP or to some other cause. Therefore, one need only show how agricultural expansion hurts the environment; the extent to which that harm is due to ATPRP will be demonstrated later when the statistical survey is carried out.

This timing, while perhaps unorthodox, will actually improve the ability to design the statistical survey. The field work carried out to show the second link, between agricultural expansion and environmental degradation, will contribute greatly to an understanding of agricultural production systems in the regions affected by ATPRP. It will give a clearer sense of how different kinds of soil are cultivated, where one may expect to see use of inputs or intensified land use, and so on. This will facilitate the design of a better questionnaire, one more likely to show the extent of agricultural growth and the importance of ATPRP relative to other factors. Moreover, it will help design a questionnaire capable of providing information on how future development strategies can minimize environmental impacts, and which mitigation techniques may respond best to ATPRP impacts.

C. Step 1: The Statistical Survey

The purpose of the statistical survey is to determine how much of the increased use of agricultural inputs or intensification of agricultural land use is due to ATPRP policy reform. This is one of the key questions to be addressed by the impact monitoring, so the two efforts should be combined rather than duplicated. Although chronologically it will be the second task in the environmental monitoring process, in terms of the logical flow of causality it deals with the first link, so conceptually it is the first step which must be considered.

The impact monitoring plan proposes a two-part process to address this issue. One part involves conducting detailed interviews with key farmers expected to increase output as a result of ATPRP reforms to find out how they have been affected.[1] The other part uses rapid rural reconnaissance (RRR) techniques to gather data about a broader group of farmers (and traders), with which (in principle) to determine the extent of impact across the larger economy. The plan does not provide much detail about how this is to be done. It does specify that it is to be done in the target crop producing regions, but does not indicate whether this means all of the provinces expected to benefit from ATPRP reforms or a more narrow target area. The plan also says nothing about attempting to obtain either a representative or a random sample of the targeted populations.

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[1] The impact monitoring plan also calls for detailed interviews with traders; however this is of less direct concern for environmental monitoring, and therefore is not incorporated in this discussion.

Rather than using RRR techniques to get at this issue, we recommend that the impact and environmental monitoring teams combine forces in conducting a broad statistical survey of farmer households concerning their agricultural activity, how it has changed during the 1990s, and the determinants of those changes. The survey should be conducted about three years after the introduction of ATPRP reforms, to allow some time for them to have an impact on agricultural output. The survey should target a carefully chosen group of households and villages designed to cover the range of agricultural activity observed in the region affected by ATPRP. An expert in survey research and sample design would have to participate in the choice of the sample, to ensure that it meets the needs of both impact and environmental monitoring. The data from the upcoming census of population will provide a solid information base for selecting the survey group; since the survey would probably not be conducted before 1998, those data should be readily available in time to make full use of them. Designing and conducting such a survey will take more than the six person-weeks of time allotted to RRR in the impact monitoring plan, so the level of effort allocated to different aspects of the impact monitoring should be reconsidered.

The survey questionnaire should cover a number of key issues:

- How much acreage did the farmer's household cultivate this year?
- Has that changed in the last five years, and how?
- If it increased, was this through cultivating new land or to shortening the fallow cycle?
- If acreage increased, what enabled the household to increase it?

This is the key question for identifying intensified land use due to ATPRP reforms. The interviewer would offer the farmer a wide range of possible factors which could make it possible to increase acreage cultivated, such as the purchase of animals for plowing, more labor becoming available due to population increase, response to demand from a trader interested in buying, and so on. Certain factors—in this case response to new demand—would indicate ATPRP impacts. The list would also include as many other factors as could reasonably be anticipated. The distribution of responses to this question would show how much of the increased acreage could be attributed to ATPRP reforms and how much is due to each of the other factors.

- On what kinds of soils has the farmer begun new cultivation or shortened fallow cycles?

The questionnaire will include a list of locally known soil types, to be developed through the field observation interviews (discussed below). The interviewer will record changes in cultivation patterns by soil type. This will provide a better understanding of how different types of soil are managed differently in response to economic opportunity or pressure, information that will be important in designing future regional land use plans which minimize environmental degradation by encouraging growth on lands suitable for use of fertilizer and pesticides, rather than on marginal land better suited to grazing and wildlife habitat.

32

- What crops does the household grow, and what is the (approximate) acreage devoted to each?
- Has that changed in the last five years—how?
- What inputs does the farmer use on each crop, has that changed in the last 5 years?
- If pesticides are used, which ones?
- Where does the farmer get inputs (ONDR, a project, the market)—has that changed in the last five years?

This will show how widespread commercial distribution of pesticides has become, and thus impact of ATPRP. It will also show the share of pesticide use that is attributable to ATPRP-created markets relative to total use from all sources.

- If inputs are purchased from a commercial source, does the farmer know where they come from, do they come with instructions for use, etc.

- How is the farmer applying the inputs—questions intended to find out whether environmental problems created by input use are worse when they are purchased commercially and applied without ONDR extension.

These questions are designed to find out whether he is buying illegal imports, which presumably come with little or no information or extension. They will also flag unsafe use of pesticides, and possibly suggest a key area for mitigation if necessary.

- Which crops does the farmer sell, which are for his family's consumption?
- To whom does he sell (CotonTchad, other villagers, in the local market to retail consumers, to a trader, through a village producers group)?

Although the results of this survey will only be indicative, they should make it possible to get a rough estimate of the extent to which agricultural expansion in the sample population may be attributed to ATPRP reforms. Since one can assume that environmental damage due to increased agricultural output is the same irrespective of the source of the increase, the same proportion may be applied to estimate ATPRP responsibility for environmental degradation, and thus USAID responsibility for mitigation.

D. Step 2: Impacts of Agricultural Expansion on Vegetation and Habitat

The second part of the environmental monitoring effort must consider the link between expansion of agriculture and degradation of the environment. In general, this link will occur through two mechanisms. Increased use of agricultural inputs can lead to water pollution through runoff of both chemical fertilizer and pesticides. Expanded cultivation onto previously uncropped land and shortened fallows directly destroy wildlife habitat on the newly cropped land and indirectly hurt the remaining habitat through the increased pressure placed upon it by humans and livestock. Such environmental degradation in turn has further implications for wildlife survival; this relationship is examined in the third step of the environmental monitoring.

32

Each of these two major impacts must be investigated separately to understand exactly how increased agricultural output—and thus ATPRP reforms—are affecting the environment.

D1. Expanding Cultivation and Shortened Fallows

The impact of expanding cultivation and shortened fallows is assessed through detailed field observation and interviews at the village level. The unit of analysis is the *terroir villageois*, or village territory. For environmental monitoring purposes, village territory is defined as all of the land utilized by villagers for cultivation, grazing, or gathering fuelwood. In terms of conventional land tenure categories, it will include privately used land, village common lands, and so-called free land which is not under the control of any one village. This definition of village territory can mean that the same land falls within the territory of two or more villages, typically such overlap of village territories will occur on land used for fuelwood gathering or grazing.

The data collection will be carried out in a total of about eight sites, which must represent the major ecosystems and agricultural production systems in the provinces affected by ATPRP reforms. Six of these will be villages. The exact choice of sites will be made by the environmental monitoring team, but should include the following major ecosystems/production systems:

- Logone flood plain, including recessional agriculture, rainfed agriculture, and irrigated agriculture (rice or gardens)
- cultivated slopes such as those near Lake Léré
- irrigated wadi garden agriculture, as near Sarh and Moundou or near Abéché
- rainfed upland bush savannah, as in the region between Pala and Moundou
- rainfed forest savannah, as around Sarh, Koumra, and to the south

In addition, two sites of comparable size will be selected within national parks, faunal reserves, or classified forests. These will be chosen to give a better picture of what the natural environment would look like in the absence of any significant human impact. The data collection on these sites will be more limited than on village sites, since farmer interviews and study of cultivation systems will not be needed.

Village and park data collection will be carried out once a year in December. This timing has several advantages: it should capture the state of the natural vegetation at or near its peak, it will be easy to see which land was cultivated in the previous season, the roads should be passable, and the air should be relatively dust-free for low-level video reconnaissance. Villagers will be relatively free from agricultural work demands, and will have more time to speak to the monitoring team.

The village data collection will be designed to show a relationship between agricultural extensification and shortened fallows on the one hand, and degradation of natural vegetation on the other. To do this, data will be collected on a number of independent variables:

Spatial limits of village territory, as defined above. This information will be gathered once at the start of the monitoring. It will be determined by using the existing 1:50,000 maps of the southern half of the country, and discussing land use with the villagers. Once determined, the limits will be mapped using a global positioning system (GPS).

Land use/land cover throughout the village territory. This information will be gathered during the first year of monitoring, based on low-level video reconnaissance data and confirmed through ground truthing and interviews with the villagers. Land will be categorized in a highly aggregate classification scheme such as the following:

upland cultivation
fallow (up to 5 years)
roads
settlements
uncultivated floodplain
recessional cultivation
permanent surface water
bare soil
grassland
shrubs
trees
canopy

The exact categories, particularly with respect to disaggregation of natural vegetation and how fallows are handled, will be determined by the monitoring team. The categories should be compatible with at least one of the major internationally recognized land use/land cover classification systems.

The land use/land cover map will be updated each year based on video reconnaissance confirmed with ground truthing and interviews as necessary. This will allow determination of how much land has been converted from either fallow or natural vegetation to agriculture each year. This is one element in the increased pressure on the remaining natural vegetation which is the key independent variable.

Population of the village territory. This will be gathered each year through interviews. Population change in the village territory is the second element needed to develop an indicator of human and livestock pressure on natural vegetation in the village territory.

Farmers' land classifications. Villagers usually have a fairly clear sense of the different types of land available in their territory and its suitability for different agricultural

activities. By understanding the potential of the land in the same framework used by the villagers, it is possible to anticipate how each area of land will be managed, and the amount of land needed to achieve a given increase in output in each area. The village territory will be mapped using the local land classification systems once at the start of the monitoring effort. In subsequent years this information will be overlaid with data on the changes in land use/land cover to develop a better understanding of village land management practices. The resulting information will also be an input into design of the statistical survey questionnaire.

Indicator of pressure on natural vegetation. This will be the ratio of village population to hectarage in natural vegetation and fallow. It might look something like the following:

$$\frac{P(t)}{20 * NV(t) + (ALF(t) * F(t))}$$

where:

P(t) = village population in year t
NV(t) = hectarage in natural vegetation in year t
ALF(t) = average length of fallows in year t
F(t) = hectarage in fallow in year t

This indicator should rise if the population increases, if land is converted from natural vegetation to cultivation or burned, or if fallow cycles are shortened. The hectarage in natural vegetation is multiplied by 20 as an estimate that a 20-year fallow might be equivalent to natural vegetation in terms of its ability to provide grazing land, fuelwood, or wildlife habitat. This indicator will be refined by the monitoring team as they actually implement the system.

The monitoring system is designed to assess the impact of increased land use pressure on natural vegetation and soil quality. To do so, the team will track three key output variables:

Area converted from fallow or non-cultivated to cultivated. This information is both an input and an output variable, since clearly the vegetation on land converted to cultivation is totally lost for other use by humans, livestock, or wildlife. It will be gathered yearly from video reconnaissance, as discussed above.

Composition and quality of natural vegetation and vegetative growth on fallow land. This will be gathered during the first year of monitoring through low-level video reconnaissance and ground truthing along a transect across each village territory or park site. It will be updated yearly based on low-level video reconnaissance, combined with additional ground truthing if necessary. This monitoring will focus on key plant species or communities which provide an indicator of the quality of pastoral resources, forest resources, and wildlife (particularly bird) habitat.

Degradation of land under cultivation. Changing land management systems, particularly the extensification of cultivation onto marginal land, is expected to lead to more rapid soil degradation. This will be measured by testing infiltration rates and soil phosphate levels on selected fields. The fields chosen for measurement will represent each land type in the local classification system, and different management practices on each land type. They will be monitored each year.

D2. Increased Use of Inputs

Data on increased use of agrochemicals will be obtained both from village-level observation and interviews and from water quality testing at selected sites in the Lake Chad and Lake Léré watersheds. In order to keep costs down, the village data collection will be carried out jointly with the field work discussed above.

The independent variables in this part of the monitoring system will concern how the farmers use agrochemicals. Data will be gathered each year with respect to the previous year's cultivation:

- What inputs were used—pesticides, herbicides, chemical fertilizer, manure?
- Where were the inputs obtained—from ONDR, CotonTchad, purchased in the market, from projects, or illegally imported?
- On what crops and what types of land were the inputs applied?
- How were the inputs stored, handled, and applied? Did the farmer have sufficient information to use them safely and effectively with minimum harm to himself, other villagers, consumers of the produce, or the environment?

This question will be a flag for possible health or environmental problems due to pesticide use. As such, it will provide input data for designing the statistical survey, which will, if necessary, obtain further information about how pesticides are being (mis)applied.

Three dependent variables will be monitored concerning water quality, one at the village level and the others elsewhere in the watershed:

Village water quality. Wells in the target villages will be monitored for the presence of nitrogen and pesticides. These chemicals may be expected to appear in wadis with self-contained interior drainage, where chemicals applied to the soil remain in the area rather than dispersing in a larger aquifer. To some extent it may be possible to predict which villages meet this criterion; however, it will probably be simpler to test all wells for the presence of these chemicals than to design a reliable system for predicting whether they will occur.

Lake water quality. Agrochemicals which flow off the land in surface runoff will enter the Lake Chad and Lake Léré watersheds. It is far beyond the scope of this project to

implement a comprehensive water quality monitoring system for those watersheds. However, we recommend limited monitoring of the water quality in those two lakes to signal the onset of serious water pollution problems. Measurements should be made twice a year, at the low and high water levels, in both pools of Lake Chad and in Lake Léré. They should cover nitrogen, phosphate, potassium, sulfur, boron, suspended solids, and pesticide residues. Although Lakes Fitri and Iro are also environmentally sensitive, they are not expected to be affected by ATPRP reforms, so they need not be included in this limited monitoring effort.

River water quality. Similar data should be gathered on the Logone and Chari Rivers at N'Djaména as an indication of pollution problems. This should be done on a decadal (10-day) basis throughout the year. In the first year this should provide a water quality signature which reflects the agrochemicals which CotonTchad is already putting into the watersheds, providing a basis for comparison with subsequent pollution levels.

If problems are observed on the rivers at N'Djaména, monitoring should also begin at Moundou and Sarh, or if possible a finer monitoring network should be developed. However, such a network will probably be beyond the scope of ATPRP environmental monitoring.

E. Step 3: Impacts of Pollution or Habitat Degradation on Wildlife

The third step in the environmental monitoring focuses on the link between water pollution or habitat degradation and wildlife populations. From a management perspective, this data collection will be combined with the village and water quality monitoring described above. Conceptually, however, it is distinct, so we are discussing it separately.

E1. Pollution

The obvious independent variable for establishing this link is water quality. This will be measured biannually in Lakes Chad and Léré, and every ten days on the Logone and Chari Rivers at N'Djaména, as described above.

The relationship between water quality and wildlife might operate in any (or all) of four ways:

- Agrochemicals in the water kill off species such as crustaceans and insect larvae low in the food chain. This eliminates the food supply available to species higher in the food chain, such as fish and waterbirds, resulting in dwindling populations.

- Some agrochemicals, including organophosphates and carbamates (as well as DDT and other hard chemicals no longer used) are absorbed by species low in the food chain without killing them. Those organisms are eaten by species higher in the food chain, concentrating the chemicals until they reach a lethal dose (or a dose which inhibits reproduction) in primary and secondary consumers such as fish and

birds. Dead animals are then seen in the water or a decline in population is observed if reproduction is inhibited.

- Toxic chemicals in the water may directly kill species such as fish or birds. This would require high concentrations, which might be present in runoff and waste irrigation water near sites of pesticide application, but would not be anticipated in Lake Chad or Lake Léré.

- Increased fertilizers in the water will enhance algae and other plant growth. When these plants die and decay they reduce the oxygen levels in the water. Invertebrates, fish, and amphibians can no longer survive in the oxygen-depleted water.

- Suspended solids and increased algae reduce the filtration of light through the water. This inhibits the growth of submerged aquatic vegetation (SAV), which in turn limits the habitat and food source of a variety of aquatic and bird species. Populations of those animals will decrease as their food supply is depleted.

Without a significant investment in aquatic biology research, it is not possible to determine exactly how water pollution will affect wildlife populations. A bird population monitoring program, combined with the development of reliable statistics on fish landings, would help develop a better sense of how wildlife is being affected by water quality, but it is beyond the scope of this monitoring effort. Developing a program to flag wildlife kills is not likely to be of much use either, because the concentration of toxins is not expected to be lethal to large animals.

The monitoring of dependent variables is therefore limited to three items:

- When the water quality monitoring is being conducted on the lakes, measurement will also be made of the **density of benthic species** in the lake bottoms. This will focus in particular on the chironomid midges, a small fly-like insect whose larvae, called bloodworms, increase in number when the water is more enriched. A change in the density of bloodworms is an indicator of eutrophication in the lakes.

- While on the lakes, measurements will also be made of the **density of plankton** in the water. This is done by dragging a plankton tow net behind the boat for a known distance or time, and measuring the volume of plankton in collected. The volume of plankton is expected to decrease as water quality degrades. As it does, one may expect to see decreases in the population of higher-level species which feed on it. By monitoring the plankton it will at least be possible to establish the link between pollution and low-level food sources. A drop in the plankton population will serve as a flag to initiate more in-depth research, although that research will go well beyond the scope of ATPRP monitoring.

- The manatees in Lake Léré will be counted from the air once a year in December, in conjunction with the low-level video reconnaissance of the village site in the Lake Léré area.

E2. Habitat Degradation

The independent variable for assessing the impact of habitat loss on animal populations is the extent of degradation of natural vegetation. When the land is totally cleared, the habitat disappears altogether, and the wildlife with it. However, when vegetation degrades gradually in response to increased human and livestock pressure, some species will disappear, some will decrease in population, and a few (such as red-billed quelea and other agricultural pests) will increase. The independent variable will therefore be the quality of natural vegetation and vegetation on fallow land, as measured at the village level in the second step of the monitoring.

The dependent variable for this portion of the monitoring will be species composition and numbers of birds. These parameters will be measured along at least two kilometers of the vegetation transects in each of the village and park sites. The counts should be done twice in each village, separated by several days if possible to control for variation due to rainfall. In the first year bird counts will be taken in all sites, recording the number of birds of each species observed along the transect.

The extent to which bird counts are needed in subsequent years will depend on the first year's observations. In the first year, observers could find a sufficient range of quality within vegetation classes to permit correlation of bird diversity and abundance with vegetation condition, facilitated by using data from the national park and reserve sites. If this is possible, then subsequent bird counts will be needed only to relate bird populations to rainfall. If not, then subsequent bird counts will be carried out in specific areas which show degradation of vegetation. This will be done each year until enough data are collected to show a relationship between the quality of the vegetation (within a specific vegetation class) and the population of birds.

F. Monitoring Schedule

The monitoring recommended in the sections above is summarized in the following table:

Timing	Activity
Year 1 in December	Village-level baseline data collection, covering: • extent of village territory • land use/land cover within the village territory • vegetation transects within village and park territory from video reconnaissance and ground truthing • manatee counts in Lake Léré, from video reconnaissance • bird counts along transects • traditional soil types map within village territory • village population • soil characteristics • water quality in wells
Subsequent years in December	• changes in land use/land cover, from video reconnaissance • manatee counts in Lake Léré, from video reconnaissance • limited ground truthing to update vegetation quality data • bird counts if necessary • village population • soil characteristics • water quality in wells
Twice per year, once at high flood and once at low flood	• water quality in each pool of Lake Chad and in Lake Léré • population density of midges on lake bottoms • volume of plankton in the lakes
Decadal all year	• water quality in the Logone and Chari Rivers at N'Djaména
Once in 1998	• statistical survey of farmers to determine impact of ATPRP reforms on agricultural production

G. Institutional Structure and Staffing

The environmental monitoring will require several different types of technical expertise, most of them during the annual village-level data collection effort. The list below suggests the kinds of different skills which will be needed; some of these could be present in the same person. For some of the data collection, particularly soil and water quality testing, it should be possible to train Chadians in the first year, and have them work under project supervision to carry out the work in subsequent years.

To ensure continuity of the environmental monitoring, it is essential that the same individuals carry out the work throughout the project. We recommend that the environmental monitoring team be recruited through the same contract as the rest of the project staff, to encourage them all to work closely together and see themselves as a single

unit. If necessary, a subcontract to an institution with the technical skills to handle GIS, interpretation of aerial images, and use of GPS may be called for.

Annual Field Data Collection:

- Agronomist/anthropologist to do interviews and manage the monitoring program. This person will have primary responsibility for the overall environmental monitoring system, and is expected to work on the project for one to two months per year. S/he will work closely with members of the impact monitoring team in designing and carrying out detailed interviews with farmers.

- Vegetation specialist to carry out vegetation transects and interpret video data. This should take one day of work per site, plus time for video interpretation.

- Soil scientist to design the soil data collection system and train a Chadian in the first year. In subsequent years this should take one to two days per village. Soil data collection will not be needed in the park sites.

- GPS/GIS/aerial photography person to manage aerial data collection. This will require about one day of work in country per site, plus additional time either in Chad or (more likely) in the United States for GIS and image interpretation work.

- Wildlife specialist for bird counts. This will be needed in the first year and possibly thereafter. Two days of work should be required per site.

Water Quality Data:

- Water quality specialist twice a year for a few days to collect and analyze data on Lakes Chad and Léré. This may be require an expatriate specialist in the first year, but by the second year it should certainly be possible to turn it over to a trained Chadian.

- Ongoing water quality monitoring capacity in N'Djaména, to monitor the Logone and Chari Rivers.

It may be feasible to contract with the Bureau de l'Eau for both of these tasks; if so, this is advisable.

Statistical Survey:

- The agronomist/anthropologist mentioned above will manage the survey and play a major role in designing the questionnaire (included in the one to two months per year estimated above).

- An expert in sample surveys will be required in 1997 (or thereabouts) to work on designing the sample and contribute to designing the survey. This may require a total of one month of work or less.

- Chadians to serve as translators, enter data, and otherwise assist in carrying out the survey. These may be identified through local projects or through other contacts established in carrying out the rest of the ATPRP project.

- A database management specialist will set up a simple computer system to enter, correct, manage, and analyze the data, and to train Chadian data-entry clerks. His/her input will be needed during survey design to ensure that the questionnaire can be automated easily. S/he will train other staff to access the data for analysis purposes.

H. Cost Estimates

The cost of carrying out these monitoring activities will depend in large measure on exactly how they are implemented. However, based on the staffing estimates above and the cost data in Annex A, it is possible to arrive at some very rough estimates which may be useful for planning purposes. These estimates do not include contractor overhead charges.

The table below gives estimated annual costs for field surveying in six villages and two park or reserve sites. Costs in the first year are substantially higher than in subsequent years, because more work and more expatriate time will be required.

VILLAGE SURVEYS	YEAR 1			LATER YEARS		
TA - Salaries	Days	Rate	Total	Days	Rate	Total
Agronomist/anthropologist	30	$300	$9,000	40	$300	$12,000
Soil scientist - expatriate	20	$300	$6,000			
Soil scientist - Chadian	20	$30	$600	20	$30	$600
Vegetation specialist	10	$300	$3,000	10	$300	$3,000
Wildlife specialist	20	$300	$6,000	20	$300	$6,000
Water quality specialist - expatriate	10	$300	$3,000			
Water quality specialist - Chadian	10	$30	$300	10	$30	$300
TOTAL Salaries			$27,900			$21,900
Video Reconnaissance:						
Mosaic per village site (from Annex A)	6	$5,500	$33,000			
Vegetation transects/updates	2	$1,500	$3,000	8	$1,500	$12,000
TOTAL Video Reconnaissance			$36,000			$12,000
Transportation:						
Kilometrage/year	2500	$1	$1,250	2500	$1	$1,250
Fuel in liters	500	$1	$500	500	$1	$500
Driver (salary & PD) in days	30	$40	$1,200	30	$40	$1,200
Expat PD outside N'Djamena	90	$100	$9,000	70	$100	$7,000
Chadian PD outside N'Djamena	30	$50	$1,500	30	$50	$1,500
Plane tickets US-Chad	5	$4000	$20,000	3	$4000	$12,000
TOTAL Transport			$33,450			$23,450
Specialized Equipment (GPS, measurement tools)			$15,000			
SUB- TOTAL VILLAGE SURVEYS			$112,350			$57,350
Less costs of agronomist/anthropologist, included in impact monitoring:						
Salary	30	$300	$9,000	30	$300	$9,000
Per Diem	30	$100	$3,000	30	$100	$3,000
Plane Tickets	1	$4,000	$4,000	1	$4,000	$4,000
TOTAL VILLAGE SURVEYS			$96,350			$41,350

The table below gives assumptions and estimated costs for the statistical survey, to be conducted three years after tariff reforms go into effect.

44

STATISTICAL SURVEY			
Assumptions:			
People surveyed			300
Number of villages:			60 (i.e. 5 people per village)
Villages per day			1
Actual survey days			60
Additional travel days			20
Planning days			20
Training days for survey assistants			15
Salaries:	Days	Rate	Total
Sampling Expert (planning)	20	$300	$6,000
Survey Assistants (2)	190	$30	$5,700
Agronomist/anthropologist	115	$300	$34,500
Database management specialist	50	$300	$1,500
Data entry clerk(s)	80	30	$2,400
TOTAL Salaries			$46,200
Transportation:	Number	Cost	Total
Kilometrage	4000	0.5	2000
Fuel in liters	800	$1	800
Driver (salary & PD) in days	80	$40	$3,200
Expat PD outside N'Djamena	40	$100	$4,000
Chadian PD outside N'Djamena	160	$50	$8,000
Plane ticket US-Chad	1	$4,000	$4,000
TOTAL Transport			$22,000
Total Survey Costs			$68,200

SECTION VI

CONCLUSION: IMPLICATIONS FOR AID

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A. The Problem

This report has addressed a specific question: how to monitor the environmental impacts of a particular set of policy reforms in Chad. There is no one ideal way to do this, especially not at a cost that may seem reasonable given the expected impact of the ATPRP reforms on agricultural output. Moreover, it is not obvious how to address environmental impacts while still allowing USAID/Chad the latitude to define its own country strategy.

It is perhaps an advantage that the potential link between non-project assistance and the environment has been brought forward in a country whose mission does *not* have an environmental program. Had the issue arisen where AID is already committed to environmental projects, significant investments in environmental monitoring or mitigation would pose fewer problems. In Chad, however, because the mission has not included the environment in its country strategy, it is impossible to avoid directly confronting the issues raised by this link.

The need for Africa missions to consider possible impacts of NPA on the environment stems from the language of the DFA enabling legislation. Section 496 of the Foreign Assistance Act requires that "policy reforms shall also include provision to protect...long-term environmental interests from possible negative consequences of the reforms." This language leaves many questions open about how much the missions must invest in predicting what those negative consequences could be or in determining after the fact what they actually turn out to be. It also does not address the relationship between the cost of the project or NPA and the cost of the mitigation effort involved.[1] The ATPRP environmental monitoring should serve as the stimulus for the Africa Bureau and the agency as a whole to step back and address some of these issues more abstractly, to understand and perhaps resolve them in general terms rather than only in the context of the needs of specific missions.

B. Monitoring—What For and How Much?

One question which the ATPRP case raises is how far missions must go to determine whether policy reforms have had negative environmental consequences. This report has espoused a view that the mission should determine three things. First, how do its actions harm the environment (if at all)? Second, what is the extent of that impact? And third, how significant is that damage in the context of other causes of environmental degradation?

[1] According to informal discussions with Edward Spriggs, General Counsel's Office, AID/W (1991) and with Rodney Johnson, Regional Legal Advisor, REDSO/WCA (March 1993).

41

While none of these questions is easy to answer in the context of policy reform, the third is the knottiest. The team has maintained that USAID/Chad should come to terms with it, however, because its responsibility for mitigation should be a function of the magnitude of its impact relative to other sources of harm, not the absolute magnitude or the percent increase in pollution. This view is intended to avoid a situation in which USAID interventions create some identifiable environmental harm—for example, increased air pollution due to ATPRP reductions on trucking costs—which is trivial in the face of the overall environmental problems faced by the country. The allocation of resources to reduce automobile emissions in Chad might seem warranted based on the percent increase in emissions attributable to ATPRP, but would be unwarranted based on the importance of air pollution relative to other environmental problems.

One could easily argue otherwise; that responsibility for mitigation should be somehow related to the absolute magnitude of the harm done, and not to USAID's contribution to the overall environmental degradation in the country. This view may be more meaningful in the case of projects rather than NPA, for which it is easier to identify specific environmental harm attributable to USAID interventions.

Determining the nature, the extent, and the relative magnitude of the environmental harms attributable to policy reforms is costly. However, the investment may provide information of use to other missions faced with similar issues, as USAID develops a better general understanding of the links between economic policy and the environment. The question should be asked, however, whether the cost of such research should be borne by individual missions, by the Africa Bureau, or by the agency as a whole. If the benefits are to be felt by all missions using NPA, then a good case can be made that small missions such as Chad should not have to bear its full costs through projects such as ATPRP.

C. Mitigation—To What End, and At What Cost?

The mitigation of environmental damage once it has been identified also raises questions. As discussed in the introduction to this report, it is easy to envisage projects for which environmental assessment, monitoring, and mitigation cost more than the project itself, especially with the current interest in small-scale projects run by local PVOs. Moreover, if mitigation is required, it can force missions like Chad to launch environmental projects outside the scope of their country strategy, for which they have neither project budgets nor management resources. This may be appropriate, in the sense that USAID activities should cover the full social (or environmental) cost which they impose. However, it will make NPA a less attractive strategy, by adding an element of unpredictability in its expenditure and management requirements.

It is also not clear what is meant by mitigation or "protect(ing)...long-term environmental interests." It can be taken to mean that it is acceptable to destroy some environmental assets if they are replaced with others, as in the "no net loss" criterion for evaluating wetlands destruction and rehabilitation in the United States. This may be a feasible criterion for evaluating projects, but it will be less useful in evaluating long-term economic reforms. In a context of population increase, dependence on subsistence

agriculture, and environmental degradation due to climatic change, it is hard to see how "no net loss" of wildlife habitat can be consistent with *any* significant increase in incomes and standard of living. Thus, while it may be possible to uphold this principle in the context of an individual project, in the aggregate it is far less apparent.

The discussion above of possible mitigation strategies for ATPRP also raises a question about how closely mitigation should be related to the harm caused. Should it attempt to correct the specific damage caused by an individual project or policy reform? To address similar problems but not necessarily in the same context? To address whichever environmental problems are of highest priority to the country, even if those are not the ones caused by the project? Or, at the other extreme, should the resources go to preventing environmental harm rather than mitigating it after the fact, as argued in the forestry annex (Annex C) to this report? Although there probably is no one "right" mitigation strategy, it may be useful to discuss this issue in the abstract and see what general principles can be developed, rather than simply leaving it to be resolved anew as each case arises.

D. Timing

The ATPRP case also suggests that USAID's standard five-year project cycle will pose problems for both monitoring and mitigation. Change in the natural environment is frequently gradual and slow, and it takes many years to observe and understand what is happening. If monitoring is integrated into the project causing the harm, the time frame is likely to be too short to show any meaningful results. Worse, it might lead to a conclusion that there is no impact, whereas in fact the impact simply has not shown up yet. It may, therefore, be more appropriate for monitoring efforts to be designed on a longer time schedule than the projects or policy reforms whose impacts they are designed to identify.

The same principle will apply to mitigation. If it is not clear what or how significant the environmental impacts will be, as in the case of ATPRP, it may not be possible to design mitigation efforts until well after the life of the project. To implement such mitigations, AID would need to adjust its management systems to allow longer time schedules for designing and implementing projects. This will limit the ability of mission staffs to develop new five-year country strategies, since they will be constrained by long-term environmental activities launched by their predecessors.

E. Conclusion

This report does not provide answers to these questions. However, by raising them in the context of the ATPRP environmental monitoring, it does attempt to shed more light on them. It has attempted to sort out the different issues involved in environmental monitoring and mitigation, and to elucidate the considerations which should factor into decisions about each issue. In doing so, the aim has been both to help USAID/Chad address the particular problems posed by ATPRP policy reforms, and to encourage the agency as a whole to face these questions throughout its project and policy reform activities.

49

BIBLIOGRAPHY

Hecht, Joy E. "Elaboration d'un Programme National de Connaissance et Suivi des Ressources Naturelles" Rapport pour la CTA/PDLCD (UNSO), January 1993.

_____, Kjell Christophersen, and Swarupa Ganguli, "Environmental Assessment in Africa" Report prepared for the Bureau Environmental Officer, Africa Bureau,USAID, by International Resources Group. (Washington D.C., 1991).

Initial Environmental Examination or Categorical Exclusion for the Chad Agricultural Trade Policy Reform Program PAAD (677-0068) and the ATPRP Project (677-0069), prepared by Robert Hanchett, Regional Environmental Officer, REDSO/WCA, prepared July 1922.

USAID Office of Analysis, Research and Technical Support, Bureau for Africa, "Plan for Supporting Natural Resources Management in Sub-Saharan Africa: Regional Environmental Strategy for the Africa Bureau," May 1992.

Weber, Fred R., "The NRM Framework: What it is, what it does, and how it works, with an example from the field" Prepared for the USAID Africa Bureau, Office of Technical Resources AFR/TR/ANR and World Resources Institute, September 1991.

World Resources Institute, "NRM Indicator Catalogue For Use with the NRM Framework," Annexed to USAID, May 1992.

ANNEX A

AGRICULTURE AND SOILS

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ANNEX A
AGRICULTURE AND SOILS

A. Introduction

When environmental monitoring is "demand-driven," it keep costs low and value high. In the case of ATPRP's environmental monitoring, the stated goal is to track environmental impacts caused by the project's policy reforms, and the assumed goal is to mitigate any resulting environmental damage. Mitigation will depend on the severity and extent of degradation as well as the value of natural resources lost. Since the PAAD states that the policy reforms are likely to have economic and environmental effects well beyond the life of the project, the monitoring program should be so designed.

Natural resource degradation is an almost inevitable consequence of economic expansion and increasing population, and we assume that ATPRP, whose purpose is to encourage economic growth, will contribute to environmental deterioration in Chad. (It is always conceivable, of course, that ATPRP reforms will result in an improved environment, but the team finds this prospect unlikely.) We should bear in mind, however, that the degree of environmental degradation is affected more by how natural resources are managed than by economic expansion and population growth.

The assumption of this monitoring program is that if indicators trade specific management techniques (e.g., shorter fallow periods on a particular soil), their contribution to environmental degradation—monitored before as well as after ATPRP reforms are initiated—can be determined. In a separate evaluation, the monitoring project will then determine the degree to which ATPRP policy reforms encourage the use of these management techniques. The scheduled end of the monitoring project in 1998 leaves only a short amount of time for the contribution to environmental degradation of newly introduced management techniques (e.g., new types of fertilizer application) to be evaluated; post-project monitoring could be funded to continue this assessment.

A1. Stratified Monitoring

A classic research problem is how to establish an independent variable's effect on a dependent variable. Statistical approaches commonly used, such as determining the effect of a particular fertilizer on crop yield, are equally appropriate for measuring the environmental effects of policy reforms. However, even when addressing questions such as yield response to fertilizer, perfect statistical correlation does not prove a relationship. A connection must still be assumed based on judgment and evidence.

The cost of a statistically valid evaluation of environmental effects of ATPRP is likely to exceed available project funds. Since the environmental effects of ATPRP program are expected to be small, evaluating them would require collecting data from numerous sites so

that statistical results are sufficiently sensitive to ATPRP-caused environmental degradation. The effort and expense may not be warranted based on the expected low level of environmental impacts (i.e., funds would be better spent on directly improving some aspect of Chad's natural environment).

Nevertheless, statistical sampling techniques can serve as a way to cut through the competing factors and help clarify ATPRP's effect on the natural environment. Although the results may not be "statistically significant," they will reduce the distance that one's leap of faith must travel in assuming causal linkages.

A2. General Approach

The general approach described in this annex follows these steps:

(1) In coordination with impact monitoring, sites are selected where agriculture is expanding, intensifying, and most sensitive to the effects of the ATPRP reforms. Monitored sites will represent appropriate management units such as watersheds, village territories, households, and fields.

(2) Indicators are monitored at the sites to determine the effect of agricultural expansion and intensification on the environment. The monitoring also results in a better understanding of factors leading to environmental degradation, so that mitigation strategies can be developed. The process involves interviews, measuring environmental quality, and the extent of the resource base.

(3) National and regional impacts are estimated through surveys and interviews, direct field monitoring, and "upstream" and "downstream" indicators such as imports of agricultural chemicals and resulting pollution in lakes and streams.

This annex identifies indicators of environmental degradation caused by agricultural expansion, indicates regions of Chad most vulnerable to degradation, and suggests strategies for mitigation. It also discusses important agricultural factors and their interactive complexity so that effective stratification and sampling can be achieved.

The annex will avoid the terms *extensification*, *intensification*, and *desertification* since they can result in confusion when used to describe causes of environmental degradation. For example, over-grazing of grasslands, over-cutting of woodlands, or shortened agricultural fallows are more descriptive terms describing processes that can result in extensification, intensification, and/or desertification.

This annex follows with a description of the natural resource base in part B, then in part C describes how these resources are managed in terms of agricultural systems. Part D discusses natural resource degradation caused by agriculture and identifies indicators of degradation, while E describes how the project can monitor these indicators. Part F briefly describes some mitigation strategies.

B. Natural Resource Base

This section begins with a description of soils, which are vital for determining both the productive capacity of agriculture as well as wildlife habitat. It also discusses the importance of topography and geology in monitoring efforts, and concludes by analyzing how rainfall affects agriculture in Chad.

B1. Soils

A clear understanding of soil types in Chad is essential to stratify sites for monitoring. Map A-1, a broad-brush soils map of the southern half of Chad (Pias, 1970) found on the following page, is divided into ten geological/climatic regions.

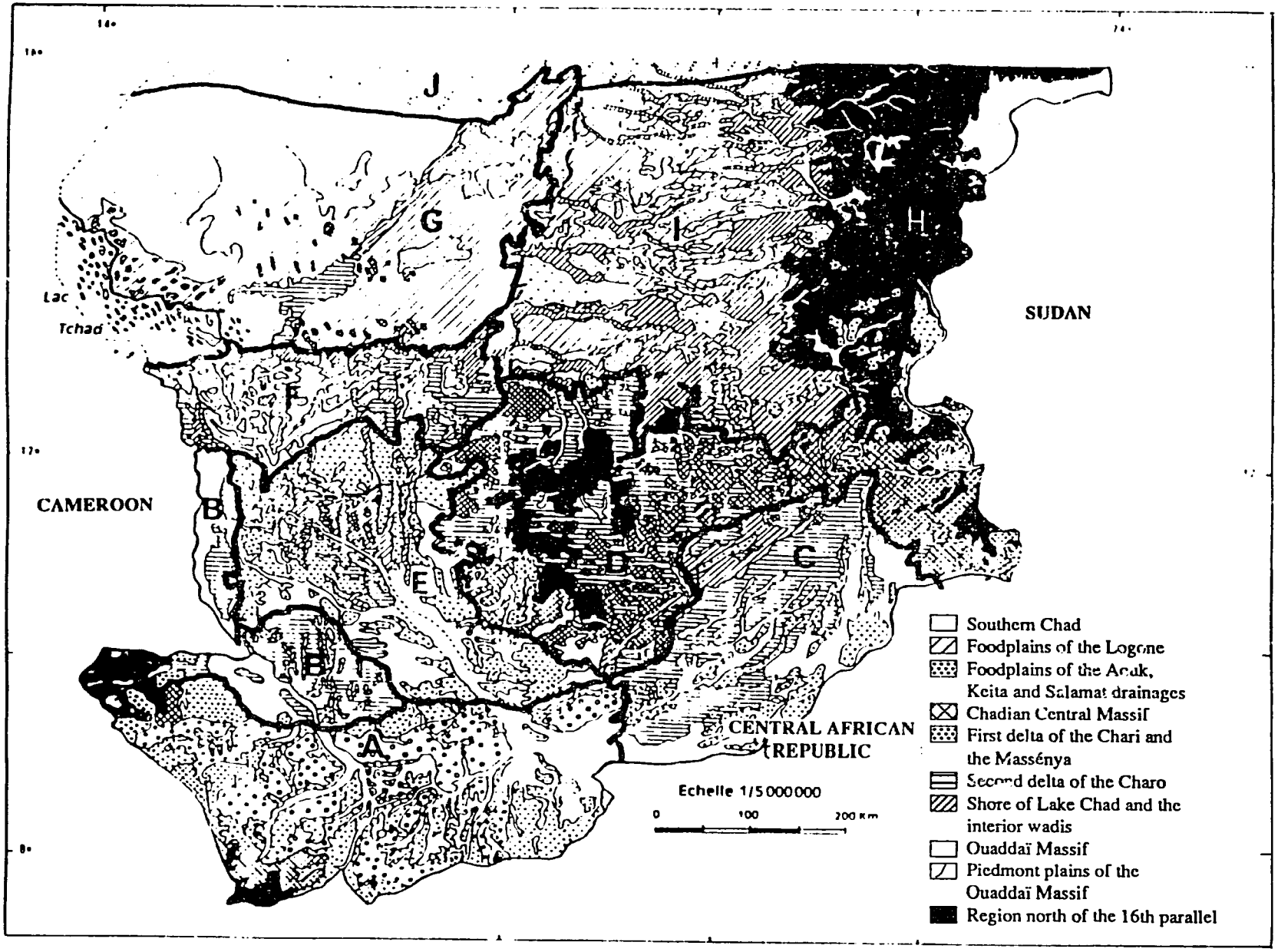
The general soil units of Map A-1 can be further subdivided into more specific units for presentation at larger scales. Numerous soil surveys have been published which cover the areas of possible ATPRP program impact. A list of surveys that include maps is presented in Table A-1 (found on page A-5). Other published soil reports that concern specific locations can also be useful for stratifying sites for monitoring. A thorough literature review should be conducted at the ORSTOM library in Bondy, France, near Paris, as well as the one at the Agropolis complex in Montpélier when developing the monitoring program. In addition to providing a baseline of information on soils, these libraries can provide other natural resource information specific to monitored sites such as hydrology and vegetation.

These scientifically classified and mapped soils are also differentiated by local resource managers, e.g., farmers and herders. Farmers and herders possess a detailed understanding of their resources. This understanding is contained, in large part, in classification systems that have evolved to describe their resources (Sturtevant, 1964; Conkling, 1969; Hunn, 1982; Tabor, 1992). For example, the Sara farmers in the village Kol near Koumra (100 km west southwest of Sarh) identify four types of soils: *kirkeon, kirkrere, nankinda,* and *nankoundoul.* Each of these identifiable soils has different levels of productivity and value, and as a result, receives different kinds management.

Indigenous land classification systems embody local knowledge about the physical and chemical properties of the land. They are shaped by such factors as the economy, management constraints, value of resources, and land tenure. For this reason, knowledge of local classification systems is a valuable tool in understanding how resources are managed and allocated, as well as how their management and allocation may change in response to new situations (e.g., new markets, improved transportation, population increases)

Indigenous classification systems can provide a simple and effective way to stratify areas for sampling and monitoring. In addition, because they are built on local terminology, these systems provide an easy means of communicating management information when conducting interviews for a monitoring program. The level of experience needed by interviewers is less important than when using scientific classification systems because much of the interpretation of resource properties is derived from resource managers.

Map A-1: Soil/Geologic/Climatic Regions



Source: Pias, 1970

Table A-1. List of soil maps, their scale, and region of coverage in Chad.

Region	Scale	Author
Chad	1:1,500,000	Pias, 1968a
Chad	1:1,000,000	Pias, 1968b
Chad south of 16° Lat.	1:1.000.000	Pias, 1970
Logone, Chari, Lake Chad, and	1:1,000,000	
Bahr el Ghazal	1: 200,000	
	1: 100,000	Pias, 1962
Abéché, Biltine, Oum Hadjer	1: 200,000	Pias, 1964a
Abou-Déia, Mangalmé	1: 200,000	Pias and Poisot, 1967
Am Dam	1: 200,000	Bocquier et al., 1968
Bokoro-Guéra-Mongo	1: 200,000	Pias and Poisot, 1964
Chari between Mani and N'Djamena	1: ?	Lepoutre, 1952
Dagéla	1: 200,000	Marius, 1964
El Amadji	1: 10,000	Pias and Barbery, 1960a
Eré-Loka	1: ?	Guichard and Barbery, 1960
Fianga	1: 200,000	Guichard, 1957
Goz d'Am-Dam	1: 100,000	Bouteyre, 1960
Kanem	1: 200,000	de Lannoy, 1991
Koumra-Moundou	1: 200,000	Bouteyre, 1965
Lake Iro-Djouna	1: 200,000	Pias and Barbery, 1965
Largeau	1: 100,000	Pias and Poisot, 1962
Logone region	1: 20,000	Bouteyre, 1956
Loka-Kabia	1: ?	Guichard, 1960
Melfi	1: 200,000	Guichard and Poisot, 1964
Miltou	1: 200,000	Pias and Barbery, 1964
N'Djamena, Massénya, Mogroum	1: 200,000	Pias, 1964b
Polder de Bol Guini	1: 10,000	Pias and Barbery, 1960b
Ranch de l'Ouadi Rimé	1: ?	Pias and Barbery, 1962
Ranch de l'Ouadi Rimé	1: 50,000	Pias and Barbery, 1961
Sarh	1: 200,000	Marius and Barbery, 1964
Satégui-Déressia	1: ?	Guichard and Poisot, 1961
Singako	1: 200,000	Bocquier and Barbery, 1968
Tikem and Daoua	1: ?	Guichard, 1962
Youé, Fianga District	1: 5,000	Bouteyre, 1955

a The list was taken from bibliographies of available documents. It has not been verified and is certain to be incomplete.
? Scale of map was not described in bibliography.

B2. Topography

Topography is an important characteristic that affects erosion and drainage, for both surface and subsurface water. The agriculturally most important areas in Chad occur on flat plains with low risk of water erosion. Problem areas for soil erosion are shown in Map A-1 as solid black units (zones rocheuses et sols d'érosion). Soil erosion on the steeper slopes in the Mayo Kebbi watershed presents the most likely and serious immediate threat to wildlife habitat degradation, especially for the Lake Léré manatees. The extensive flat areas of river, ephemeral stream, and lake floodplains are the major potential source of agricultural pollutants.

B3. Geology

The ATPRP program is unlikely to cause degradation of Chad's geologic resources. The Lake Chad basin is predominantly composed of acidic rock and sediment; these contribute relatively low amounts of "minerals" or basic ions (e.g., Ca++, K+, Na+) to the lake. This among other factors has kept the lake from going saline.

There are exploitable deposits of limestone and marble near Léré and Pala (Kusnir, 1993). These deposits could be converted into important agricultural inputs as the Chadian economy improves and financial benefit from applying lime to fields is possible. A lime kiln already exists nearby in Cameroon and should supply Chad's initial demand for agricultural lime.

B4. Rainfall's Spatial and Temporal Variability

Rainfall has the potential to dwarf any degradation caused by ATPRP over the short period allowed for project monitoring. Environmental monitoring should show variation in rainfall and be able to separate its effect on environmental degradation from the policy reforms of ATPRP.

The total amount of rain that falls is often less important than how it falls. If a drought period occurs when a crop is flowering, especially for determinate plants (plants flowering only once during the growing season), it can devastate yields. Flash floods on floodplain agriculture can be equally devastating. Soil water infiltration rates largely determine how much rainfall can be stored in the soil and how much will be lost through runoff, potentially causing erosion downstream. Sahelian zone rain-fed agriculture is exclusively practiced on soils with high infiltration rates (9 to 13cm/hr). Sahelian and Sudanian rainfall is intense and highly variable and it is important that the soil be able to absorb as much rainfall as possible. Rainfall intensity was studied at Bambey Senegal (located in a 650 mm/yr rainfall zone). Results showed that half of the annual rainfall fell with an intensity greater than 27 mm/hr. A quarter of the rainfall fell with an intensity greater than 52 mm/hr. The peak intensity was 37 millimeters in 3 minutes (740 mm/hr). During most years, brief periods with intensities of 100 mm/hr are recorded (Charreau & Nicou, 1971; Jones & Wild, 1975).

The spatial variability of rainfall is also important. Sahelian farmers often spread their fields over large areas, up to five km and even further from their homes. In part, this strategy helps them cope with high spatial variability of rainfall by reducing the chance for total crop failure due to localized droughts.

Chad's diverse agricultural systems are a result of its diverse hydrologic systems (e.g., river, stream, and lake floodplains). These systems are affected differently by rainfall and have different kinds and degrees of risk associated with them.

The stratification of land management and environmental degradation data by "water-type year" is essential in order to separate degradation caused by ATPRP from that

51

caused by climate (Warshall et al., 1989, pp. 54-59). For example, imagine a region dependent on both rain-fed and recessional agriculture. During one year, rainfall is very low but river flooding is good. The resulting management strategies of each village in the region will depend both on the land resources and the different water-type year experienced for each farming system. A village without recessional agricultural land may have to ransack its natural resource base; another with lots of recessional land may decide to invest heavily in recessional agriculture for this particular year (this may include using agricultural chemicals available through ATPRP reforms.)

C. Management of the Resource Base

Land management decisions are usually made at the household level, based on risk and return on investment. In addition to the natural and human resource base of a household, numerous social, political, economic, and infrastructural factors influence land management decisions. In Chad, these factors may be less predictable than rainfall and as a result have more bearing on how farmers manage the land. Once the major factors are known, outsiders can more easily understand and predict the behavior of resource users in a dynamic environment.

The degradation of natural resources through "poor" management is usually justified by short-term financial and economic considerations. Resource-users (e.g., farmers, wood-cutters) and governments make decisions to forego conservation because the short-term loss in income (investment of labor and capital) is judged to be excessive.

This section outlines the major agricultural systems that occur in Chad and describes the expected effects of the ATPRP on each of them.

C1. Rain-fed Agriculture

Rain-fed agriculture practices in Chad are dictated by the rainfall gradient, which runs from the drier Sahelian bio-climatic zone to the Sudanian and Guinean zone.

C1a. Sahelian Zone

Rain-fed agriculture is unlikely to receive any ATPRP-influenced inputs in the Sahelian zone, mainly because of the risks associated with drought. Farmers in this zone will put their agricultural inputs into crops grown under less risky recessional and irrigated systems. As demand for food increases, rain-fed agriculture will expand into more marginal land and fallow periods will decrease. Chemical fertilizer is the least likely input to be used since animal manure is available and, as farmers know, a healthy fertilized crop is more susceptible to drought than an unfertilized crop. Of the major rain-fed commodity crops grown in this zone (millet, sorghum, peanuts, and cowpeas) the indeterminate ones (peanuts and cowpeas that flower throughout the growing season) are the most likely to receive agricultural chemicals.

C1b. Sudanian and Guinean Zones

Cotton, peanuts, cowpeas, millet, sorghum, maize, sesame, and taro are the most common commodity crops grown in the Sudanian and Guinean zones. Of these crops, cotton is the only one receiving chemical fertilizer and pesticide inputs. This use of inputs is dependent on the support of CotonTchad and ONDR. Farmers exploit residual chemical fertilizer left in the soil after a cotton crop by following it with another crop, usually peanuts, millet, or sorghum.

Striga, a parasitic weed, is the major crop pest and a major reason why farmers return their fields to fallow. Presently the only practical way to control this weed is to allow the population of viable striga seeds to diminish through a fallow period greater than two years. Since the soil becomes noticeably more fertile during this fallow period, many farmers falsely equate high soil fertility with low populations of striga, and use striga as an indicator of soil infertility. (Locusts and granivorous birds are generally considered to be the worst animal pests.)

Eventually, through the growing Nigerian markets, financial incentives are likely to force widespread use of agricultural chemicals for production in this zone. Currently, however, lack of markets, lack of credit, and small profit margins discourage use of agricultural chemicals. It is in the farmers' financial interest to clear forests (if land is available) or reduce fallow periods (if land is scarce) instead of increasing production on existing cultivated land through inputs of material and labor. As in other parts of West Africa, sustainable intensification of land-use will occur first where the demand on land for food is so high that migration from the village territory is the only other alternative. Change in resource tenure and usufruct (e.g., rental rights) could encourage sustainable intensification and slow habitat destruction but is an unlikely short- or medium-term strategy.

C2. Recessional and Rainy Season Rice Agriculture[1]

Recessional agriculture has been a much neglected farming system in terms of donor interest and support. Like well-managed irrigation perimeters, it provides low risk from drought but with limited or no capital investment. Also, it is less of a political problem for allocating international water rights than irrigation development.

Chad has several distinct types of recessional agriculture from the flooding of rivers, lakes, ponds, and streams. Soils, type of flooding, and markets determine the kinds of crops grown; it matters little whether the site occurs in the Sahelian or Sudanian zone. Sorghum, maize, tomatoes, garlic, and onions are the most common recessional commodity crops and all are expected to receive agricultural chemical input once financial incentives and markets exist.

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[1] For organizational purposes rainy season rice was included with recessional agriculture since it occupies the same sites and the soils.

Water pollution from agricultural chemicals is much less likely for recessional crops than for rain-fed or irrigated cultivation. Pesticide pollution should be low because of the long period (the hot season) between application of pesticide and the next chance for pesticide runoff (the rainy season). This long period will destroy many, but not all, pesticides. Fertilizer pollution will not be a problem because farmers do not fertilize recessional crops and are unlikely to do so in the near future. This is primarily because application is required before flooding of the field and long before harvesting. Agronomic research and extension will be required before farmers consider fertilizing their recessional crops. The potential for fertilizer losses to runoff and resulting pollution from recessional agriculture is a medium- to long-term concern.

Rainy season rice is likely to create the largest ATPRP generated demand for agricultural chemicals and is expected to be the largest source of non-point pollution, especially pesticides, to Lake Chad. Risk of drought will be reduced in areas where inexpensive diking can control flooding on fields. With this reduced risk, investments in fertilizers and pesticides will be rewarded with large yield increases. However, the lack of adequate extension, the time needed for dike construction, and experimentation with agricultural chemicals and water control may delay the farmers' response until after project impact and environmental monitoring have been completed.

C3. Irrigated Agriculture

Riverbanks, wells, and poldors are the major forms of irrigated agriculture in Chad. Irrigated agriculture has the potential to be a major water polluter, but the development and recurrent costs involved in riverbank and well irrigation make extensive private development of perimeters unlikely until most of the rainy season rice and recessional sorghum lands are fully developed. Poldor irrigation could be very profitable since there are no pumping costs involved and poldors have the most fertile soils in Chad (Pias, 1970). However, poldors are minor in extent with little possibility for expansion, and do not constitute a serious threat to the natural environment.

Vegetable gardens and project-supported rice perimeters are currently the only significant users of agricultural chemicals outside of the official support of CotonTchad. Vegetables, rice, maize, wheat, cotton, and sugarcane are the crops most likely to receive agricultural chemical inputs in the near future. Monitoring for environmental degradation from irrigated agriculture can be approached as a point source problem, unlike the other agricultural systems that are primarily non-point polluters and much more difficult to monitor.

D. Natural Resource Degradation Resulting from Agriculture

The health of one natural resource is usually connected to that of another. The "food-web" is an ecological concept that encompasses this relationship. Wildlife is dependent on habitat, which is often characterized by vegetation, soils, and water. Agricultural systems, to varying degrees, replace the natural vegetation with crops and in the

process also degrade soils, water, and increasingly the atmosphere (e.g., through deforestation).

The following discussion identifies indicators of degradation as well as those regions most vulnerable to degradation.

D1. Indicators

Effective environmental monitoring measures characteristics which are sensitive to change or which represent degradation most likely to need mitigation. These may include management techniques, resource quality and quantity, etc. The overriding constraint on monitoring is project management limitations: budgets, timing, and accessibility. The balance achieved between project limitations and requirements for effective monitoring determines the quality and quantity of monitoring possible.

The indicators described below were selected based on the constraints of the project. They are presented in terms of the resources most likely to be degraded by agriculture: wildlife, vegetation, soils, water, and air. More effective indicators may be identified through the monitoring project as more is learned about the different farming systems' impact on environmental degradation

D1a. Wildlife Degradation

Agriculture devastates wildlife populations indirectly through the destruction of their habitat. Replacement of natural vegetation with crops and pollution of waters with agricultural chemicals and sediment are the major causes. Bird kills and over-fishing of rivers and lakes are other wildlife concerns; they are addressed in Annex E of this report.

D1b. Vegetation Degradation

Agricultural expansion and the resulting degradation of natural vegetation are the biggest threats to wildlife and biodiversity. Vegetation degradation occurs through opening new lands to agriculture, fragmenting habitat, shortening fallow periods, over-grazing pastureland, and over-cutting woodlands. The effects of agricultural extensification and intensification on vegetation can be evaluated by monitoring changes in land-use management and vegetation quality relative to soil types and village territories.

Indicator: fallow period - vegetation quality

Complicating factors: soil type, soil resources within village territory, biotic zone, and land management history (e.g., burning, grazing pressure and fuel-wood cutting).

Monitoring methods: village and household interviews, descriptions and ground referencing of vegetation quality, measurement of "fields," and time-series monitoring with high resolution remote sensing.

Since much of the land in the Sudanian and Sahelian zones of Chad has been cleared or degraded by man, the length of fallow periods on each soil type is likely to be a good indicator of vegetation degradation. Once the relationship of vegetation quality and fallow periods is better understood through village and household monitoring, regional impacts of ATPRP on vegetation degradation may be determined though a survey using simple questions. Monitoring land-use with a time series of high resolution aerial video transects provides a relatively inexpensive alternative to standard aerial photographs or satellite images that were not considered for ATPRP owing to cost.

Fallow periods are a function of the quantity and quality of land available, demand for food and income, land management, and climate. Agricultural land-use follows village resource tenure laws and usufruct that define a village territory (VT) for each village. Since the VT is a unit of management it should be monitored as a unit. Land allocation across village territories generally follow a first claim basis although village division and land allocations to immigrants result in division of the initial territory. Territories vary greatly in size and quality of land within them. Within a VT, agricultural land is managed by households; equitable distribution of quality and quantity of land to each household should not be assumed. Once the available resource base of a VT and the individual households within it are known, then land management decisions and the resulting fallow periods can be understood.

As the demand for food and income from the land increases, households are forced to use more marginal lands within the village's territory. In most cases this land is less productive and responds poorly to labor and material inputs as compared to the better land already under cultivation. In some cases the marginal land is more erodible and it quickly and permanently loses its productivity. Since the marginal land produces less, much more land must be converted to generate a given increase in food or income. As demand increases further the common management technique is to reduce the fallow period, at a cost of lower productivity. The regenerative effect of fallow periods on soils is discussed in the following section. Other aspects of vegetation degradation are discussed in Annex B on range resources and Annex C on forestry.

D1c. Soil Degradation

Agricultural extensification and intensification can result in soil degradation, which can reduce production of food (e.g., crops for humans, natural vegetation for wildlife). Degradation by erosion also pollutes aquatic habitats as well as the air. Table A-2 on the following page shows the decrease in soil fertility that can occur with continued cultivation, especially with the important fertility characteristics of organic matter content and cation exchange capacity.

Table A-2. Evolution of chemical characteristics with regard to the period of cultivation for soils (0-10 cm deep) in the Casamance of Senegal (Pieri, 1989).

		Years in cultivation			
		3	12	46	90
Organic matter (%)	2.85	2.49	2.02	1.14	0.84
Total nitrogen (%)	0.90	0.79	0.68	0.43	0.35
pH	6.33	6.00	5.88	5.98	5.92
CEC[1]	7.8	5.2	3.7	3.8	2.5

[1] Cation exchange capacity (i.e. the soil's ability to hold positively charged nutrient ions).

Considering project constraints, only two indicators are proposed to monitor soil degradation; (1) fallow periods, also used to monitor vegetation degradation, and (2) signs of erosion (e.g., gullies).

Indicator: fallow period - soil fertility

Complicating factors: soil type, slope, soil resources within village territory, biotic zone, land-management history (e.g., crops grown, fertilization, soil and water conservation practices, burning).

Monitoring methods: village and household interviews, soil descriptions and mapping, soil analysis at site or in laboratory, measurement of fields, and time-series monitoring with high resolution remote sensing.

The regenerative effect of fallow periods on soil occurs through: (1) reduction in weeds and pests (e.g., the population of viable striga seeds in the soil decreases over time), and (2) improvement in soil fertility. Improvement in soil fertility during fallow periods occurs when deep rooted plants exploit the soil for nutrients and concentrate them over time near the soil surface through decomposition of leaves and roots. This decomposition of leaves and roots also increases organic matter content (Table A-3). The increase in organic matter and biological activity (e.g., termites) improves other aspects of soil fertility (e.g., increased water infiltration rates).

Table A-3. Organic Matter Content of Vertisols along the Chari River, 30 km south of N'Djaména (King, 1980)

Depth (cm)	35-year fallow	3-year fallow[2]
0-15	2.5%	1.8%
15-30	1.2%	1.0%
30-45	1.1%	0.9%

Soil erosion is one of the major factors affecting soil productivity, but it is extremely difficult and expensive to monitor accurately. The models commonly used to estimate erosion losses in the United States are not calibrated for Chad. Erosion strips the soil of its most fertile layer, high in organic matter and nutrients. It greatly affects surface characteristics that influence water infiltration and runoff. Besides reducing soil productivity, water erosion causes degradation of aquatic habitats by increasing siltation, eutrophication, and turbidity of the water. Wind erosion and the resulting dust contribute to air pollution.

Considering the difficulty in directly monitoring soil erosion and its importance in environmental degradation, erosion should be monitored by a proxy indicator. This is accomplished by monitoring those characteristics that are (1) directly observable effects of soil erosion (e.g., number and size of gullies in a field), and (2) factors affected by erosion that represent environmental degradation (e.g., decreasing water infiltration rates, sediment loading of streams and rivers).

Indicator: signs of erosion (e.g. gullies) - soil erosion

Complicating factors: too numerous to consider. Numerous ground observations and interviews required to determine regional extent. Severity is subjective.

Monitoring methods: interviews and field observations.

Additional proxy indicators exist to monitor soil erosion and loss of soil fertility, but they require more labor and funding than is available in the project (unless some NGO or volunteer organization located at monitored sites is willing to collect the data). During the design of ATPRP monitoring, if a capable organization in one of the monitored villages is willing to help with monitoring activities, then several additional indicators should be considered.

Water infiltration rates (using a disk permeameter) and soil phosphate concentrations will meet the need for proxy indicators. Both are relatively simple and inexpensive to measure and their spatial variability within a field-size area is usually relatively low. Both are very sensitive to the effects of erosion and organic matter losses encouraged through cultivation.

[2] Cultivated for 10 years prior to fallow.

Indicator: water infiltration rates - soil productivity

Complicating factors: soil and crop specific, land management history, erosion, and soil fertility. Results must be related to land-management technique before extent can be determined through interviews.

Monitoring methods: time-series, soil/site specific field measurements using a disk permeameter.

The rate of water infiltration can be a good proxy indicator because it is dependent on numerous soil characteristics that affect productivity, including soil structure, organic matter content, biological activity, texture, compaction, and crusting.

Disk permeameters (Perroux and White, 1988) are a relatively new tool used to measure water infiltration of soils, among other things. They cost approximately $800 each and some models are very portable. All models use relatively little water, approximately 2 liters per measurement, compared to the standard double ring infiltrometer. Measurements are relatively fast, taking from 15 minutes to an hour per measurement, and have results comparable to the double ring infiltrometers with less inherent variability. Previous studies that used double ring infiltrometers to monitor effects of cultivation on permeability could not show significant differences between degraded and non-degraded sites (Pieri, 1989, p.111). However the disk permeameter has been used to clearly show soil degradation in Senegal and Mali (Tabor et al., 1993). One person with two disk permeameters should be able to take 10 to 20 measurements per day depending on the infiltration rates. Ten measurements per quarter hectare area should give a good distribution of rates to compare with the same site in different years as well as other sites.

Indicator: soil phosphate concentrations - soil fertility

Complicating factors: soil specific, land management history, and erosion. Results must be related to land-management technique before extent can be determined through interviews.

Monitoring methods: time-series, soil/site specific field sampling, and laboratory analysis.

Soil phosphate concentration is a good indicator of soil fertility because it is a relatively immobile, stable soil nutrient. Inexpensive, simple colorimetric methods are available to measure soil phosphate concentrations. Spectraphotometers exist in N'Djaména at various laboratories. If need be, air-dry soil samples can be stored for years until the results are needed. Sampling should be collected at the same time and sites as the disk permeameter measurements.

D1d. Water Pollution

Water pollution could be the most serious environmental problem for Chad. Unlike most lakes, lakes Chad and Fitri cannot be flushed clean. Pollutants must degrade or be isolated through biological, geochemical, and hydrological systems that are poorly understood. Of the possible water quality indicators that can be monitored, pesticide pollution provides the most direct link to increased use of agricultural chemicals that ATPRP will encourage directly or indirectly.

Indicator: pesticides in water - water pollution.

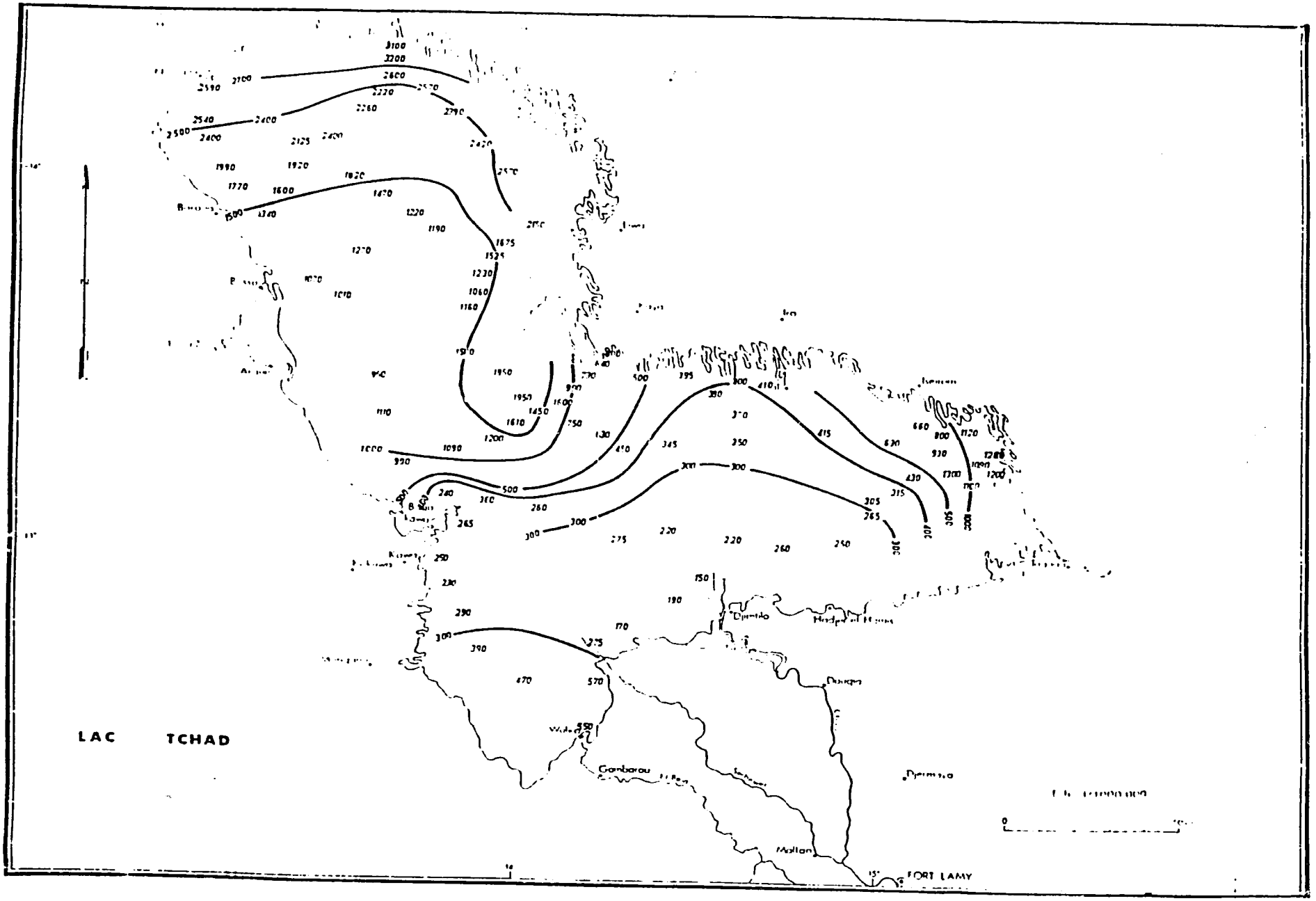
Complicating factors: does not indicate severity of problem.

Monitoring methods: periodic water sampling, sample preparation, and shipment of sample to foreign laboratory.

Water quality monitoring is needed to give a quantifiable measure of environmental degradation caused by agriculture. This monitoring will be especially useful to act as a "downstream" warning flag of potential pesticide problems.

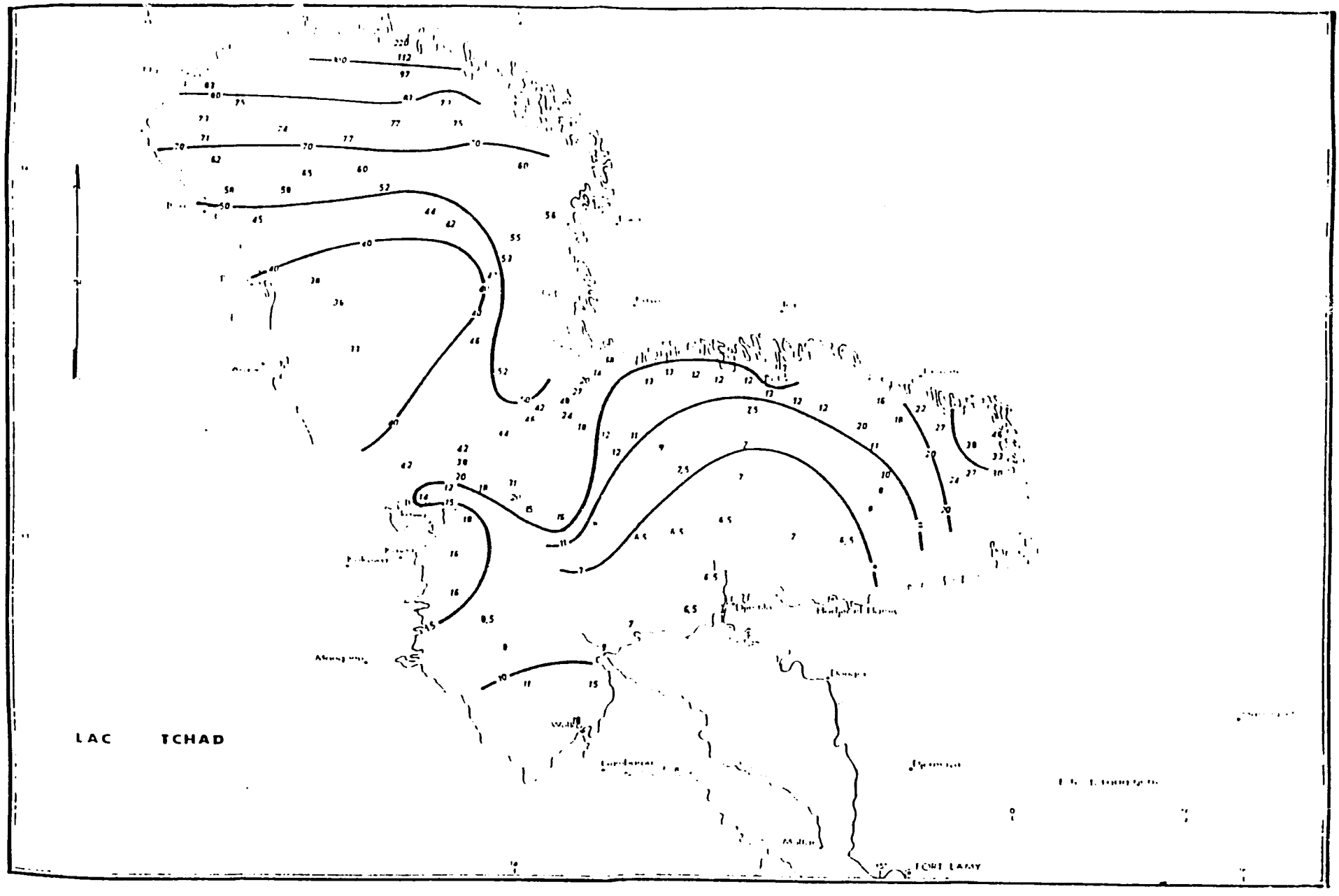
Rainfall induced spatial and temporal variability of chemical concentrations (e.g., "minerals") in river and lake water (see Maps A-2 and A-3, and Tables A-4 and A-5, on the following pages) will greatly affect water quality and mask any minor changes caused by agricultural extensification or intensification. This constraint limits the short-term value of monitoring for increases in erosion and fertilizer pollution.

Map A-2: Distribution of Phosphates (PO_4 in µg/l) in Lake Chad



Source: Carmouze and Pedro, 1977

Carte A-3: Distribution des Ions K+ Exprimés en me/l x 10^2



Source: Carmouze et Pedro, 1977

Table A-4. Variation[1] of the chemical composition of Lake Chad water (percent molarity relative to sum of cations [Carmouze and Pedro, 1977]). The higher the number, the higher the relative concentration of the particular mineral component.

	[Ca+2]	[Mg+2]	[Na+]	[K+]
1967	20.8	16.8	47.8	14.5
1972	13.7	14.6	57.3	14.4

[1] Between 1967 and 1974 the lake level dropped 2.5 m and surface area decreased from 21,000 km 2 to 2,500 km2

Additional information on water is provided in Annex D.

Table A-5. Average chemical composition in mg/l of Chari River and Lake Chad waters (Carmouze and Pedro, 1977).

Constituent	Chari River	Lake Chad	Concentration coefficient
Si(OH)4	22.2	46.7	2.1
CO3H-	31.5	247.7	7.8
Ca+2	2.06	12.50	6.0
Mg+2	0.94	6.20	6.6
Na+	2.92	33.6	11.5
K+	1.84	16.81	9.1
Total	61.50	363	5.9

D1e. Air Pollution

Air pollution caused by increased agricultural activities of ATPRP is expected to be trivial (e.g., road dust, CO_2 emission from increased truck traffic) in relation to dust-laden Harmattan wind or U.S. emissions of CO_2. Dust from wind eroded fields in the Sahelian zone contributes to the Harmattan dust, which originates in the Sahara. However, it is the resulting soil and vegetation degradation in this region that should motivate conservation actions, not air pollution.

D2. Vulnerable Regions

Lakes Chad and Léré, watersheds of the Aouk, Keita, and Salamat drainages, and wadis of the Sahelian zone are important wildlife habitats extremely vulnerable to degradation. The likely causes of degradation to these areas are described below. ATPRP policy reforms are likely to have some impacts on these areas but should be minor in the context of inevitable long-term environmental degradation.

The death of Lake Chad was predicted in 1947 (Jacques-Felix); river-pirating of the Logone by the Mayo Kebbi will in geologic time leave Lake Chad a dry basin. However, this eventual geologic death may be preempted by agricultural chemical poisoning. Lake Chad is the sump for waterborne pollution from most of Chad and parts of Niger, Nigeria, Cameroon, and Central African Republic. Its self-cleaning mechanisms, especially the biological ones, are not sufficiently understood to predict the environmental effects of agricultural chemicals. Pesticide poisoning of birds and aquatic life and eutrophication effects such as fish kills from resulting low oxygen levels in the water can be expected if agricultural development within the Lake Chad Basin is not controlled. The eventual death of the lake by pollution and salinization would be catastrophic to wildlife as well as dependent agricultural production. ATPRP policies that encourage the use of agricultural chemicals will share in the responsibility for Lake Chad's health.

Lake Léré is part of the Mayo Kebbi-Niger River watershed and is geologically interesting because it also receives water from the Logone River that empties into Lake Chad. Lake Léré is invaluable in terms of biodiversity and evolutionary science since it harbors a population of manatees. The lake is vulnerable to siltation and agricultural chemical pollution that may be encouraged by ATPRP policy reforms. Siltation will result from expansion of agriculture on the easily erodible hills within the lake's watershed. The main source of agricultural chemical pollution will be the expected expansion of rainy season rice in the part of the Logone River floodplain that partially drains into the Mayo Kebbi.

Lake Iro and the surrounding watersheds of the Aouk, Keita, and Salamat drainages (Moyen-Chari, Salamat, and Ouaddaï prefectures) have relatively high populations of wildlife and are the most vulnerable to agricultural expansion. Significant production of recessional sorghum already occurs but it is far from its potential. Rainy season rice and recessional sorghum production will probably drive agricultural expansion once transportation in the area is improved and more profitable markets for rice and sorghum develop. ATPRP policies that increase profits to farmers and markets for grain will encourage agricultural expansion and will share in the responsibility for habitat destruction in this region.

Wildlife dependent on wadis is threatened by agricultural development. Wadis occur in Regions G, H, I, and J of Map A-1 (Kanem, Batha, Ouaddaï, and Biltine prefectures). Some wildlife species, however, may benefit from agricultural development activities such as properly designed water retention dams that can provide surface water for longer periods into the dry season. Long-term threats to wildlife are pesticide poisoning and agricultural chemical pollution of Lake Fitri by runoff water from the wadis.

10

E. Monitoring Indicators of Degradation

Several methods will be used for environmental monitoring: (1) interviews will be conducted in order to collect historical and current information and to help monitor land management practices and the processes of degradation, (2) sites will be visited to measure land-use changes and possible degradation, and (3) remote sensing (i.e., video reconnaissance flights) will be used to measure land-use changes and possible degradation in a more accurate and cost effective way. Environmental monitoring activities will be integrated as much as possible with those of the impact monitoring.

Interviews. Environmental monitoring questions will be included with impact monitoring questions. The interviews, for groups or individuals, should last one hour. A tour through the village territory should be conducted by some authority of the village to point out examples and to discuss topics in more detail. Tasks of men and women are different as are their knowledge and perceptions of their environment, so questions should be directed to the appropriate people. Table A-6 on the following page provides a draft outline of topics that should be considered during interviews.

E1. Site Measurement

Site visits are needed to determine accurately the quantity and quality of resources. Most of the site visits will occur along with initial village and household interviews. Only recently has the technology existed accurately, easily, and inexpensively to identify spatial areas and point locations from the ground. Through a network of satellites, the Global Positioning System (GPS) allows GPS receivers (ranging in price from $200 to more than $3000) accurately to determine location (coordinates and elevation). It is essential that accurate site locations be recorded along with descriptions of observations for spatially dependent data. GPS receivers will allow the use of nationals as data collectors. Many technicians (expatriate and nationals) have difficulty locating themselves on maps or aerial photographs but otherwise are competent. Inexpensive receivers (e.g., Sony) can be used by monitors where speed is not important and only location is needed; however, faster (e.g., reading in 2 seconds vs. 20 minutes), more expensive models with numerous functions will be needed for this monitoring program.

E1a. Soil Erosion

The symptoms of soil erosion (e.g., gullies, exposed roots) that are observed during monitoring activities will be described (e.g., extent, severity) and location recorded for possible monitoring.

Table A-6. Possible interview topics[3] (divide into questionnaires for villages, households, individuals)

Social/General

- Village and location relative to a major town
- Ethnic group/language group
- Age and social class
- Gender
- Name

Soil

- Types of soils[4] (each type) (village and households)
- Description of soil (answers can be gender-influenced)
- Location on landscape/village territory
- Plants/trees that only grow on this type of land
- Relative value/crop yields as compared to other soils
- Variability of productivity, spatially and temporally

Agriculture

- Management techniques (answers influenced by gender, rainfall-type year, etc.)
- Amount of land cultivated, in fallow, rented
- Presence of erosion, fire damage, etc.
- Crops and cultivars grown, when and why
- Any use of agricultural chemicals, how used, how acquired
- Agricultural chemicals, seeds
- Use of animal manure; when, where, and how
- Pests, weeds, and disease
- Yield differences under different management, why

Labor

- Labor resources (households)
- Family labor, numbers, gender, time spent, and duties
- Hired labor, plowing, weeding, harvesting, etc.

Other Economic Issues

- Capital (households)
- Businesses
- Remittances
- Depth to water in well, end of rainy season, end of dry season
- Type, cost, and availability of transportation by season
- Livestock, plow, cart, etc.
- Debt
- Water resources (village)
- Markets (village)
- Transport (village)

[3] Historical as well as current information should be collected.

[4] It is important that soil specific information be separated by soil type. If responses encompass all soils or groups of soils, the information should be presented generally.

72

E1b. Boundary Identification

Boundary identification of monitored units (e.g., village territories, soil types, fields in different stages of fallow, field ownership of monitored households) can be accomplished by walking or driving the boundary lines with a GPS receiver and entering reference points into the receiver's memory bank. This will occur during the initial and subsequent visits to villages. Field notes on spatial information should include GPS coordinates.

E1c. Vegetation and Crop Identification

Some ground referencing will be needed to maximize the usefulness of aerial video images (described below) used to map natural resources and land-use. A GPS receiver will be used to record location of observations on field notes and, in the case of transects, to identify the location of the flight line on the ground.

E1d. Pesticide Monitoring

Pesticides should be monitored in the Logone and Chari Rivers at N'Djaména and the two pools of Lake Chad. The monitoring of the rivers should be conducted at different times over the annual hydrologic cycle since the various pesticides follow different pathways. Further division of the watersheds as well as monitoring ground water around irrigated areas would separate sources of degradation and pollution.

E2. Aerial Video Recording

Remote sensing is used to gather spatial information because ground observations alone can not provide the accuracy and quantity of information needed to determine land-use changes and indirect ATPRP impacts. Aerial video recordings were chosen over other forms of remote sensing (e.g., aerial photographs, satellite images) because of their very high resolution, relatively low cost, adaptability, and immediate availability. Because they are made at low altitudes, they may be perceived as less threatening by the Chadian government than the much higher altitude flights needed for standard aerial photography. Presently, private aircraft are available in Chad for this kind of work.

Aerial video recordings have been used to monitor land-use in a USAID-funded study of the Senegal River Valley (Marsh et al., 1990) and a NASA study of the Guinea Highlands (Gilruth and Hutchinson, 1990). These studies found that they provide a relatively low cost, high resolution alternative to aerial photographs and satellite images. The images are easily digitized and converted to photographs and GIS databases.

Aerial video recording would be flown over selected villages after their territory boundaries have been identified. The video will (1) determine extent and quality of soil and vegetation resources, (2) verify information collected through village and household interviews, (3) help monitor land-use change, and (4) help in the development of environmental questionnaires. The villages selected will be based on impact and environmental monitoring criteria that are biased toward those villages most likely to be

affected by ATPRP reforms and environmental degradation. Very long (e.g., 100 km) aerial video transects can be recorded along the flight lines between selected villages to provide additional pre- and post-policy land-use information. Table A-7 outlines the estimated cost involved in conducting aerial video recording and analysis of the data.

Table A-7. Estimated unit costs, excluding overhead, for conducting an aerial video land-use analysis of village territories.

Remote sensing specialist	$320/day
Remote sensing technician	$15/hr
Plane and pilot (e.g., 100 km/hr coverage)	$300/hour
Equipment rental	$200/day
Video tapes	$10/2-hours
Village territory[5] (costs assume 7 km x 7 km, or 50 km^2 area)	
Mosaic of territory	$1500
Digitize maps	$1000
Boundary mapping (e.g., fields, soils)	$1500
Vegetation mapping	$750
Land-use change analysis[6]	$750

E4. Import and Export Monitoring

Tracking of ATPRP-influenced imports and exports, as foreseen in the impact monitoring plan, will allow the environmental monitoring to adapt to unforeseen environmental hazards (e.g., unexpected use of fertilizer in a particular region of the country).

F. Mitigation

In general, mitigation of environmental degradation can take the form of policy improvements, infrastructure development, and institution building. The severity and extent of environmental degradation and the value of natural resources lost should determine the type of mitigation activities. Possible forms of mitigation that USAID should consider are described below.

[5] Ground referencing with GPS coordinates integrated into other monitoring activities.

[6] Analysis based on subsequent flyovers.

74

F1. Policy Improvement

Natural resource tenure laws and usufruct need improvement. They need to be region-specific to accommodate the interests of farmers as well as herders. Also, areas of important wildlife populations should have laws that discourage habitat destruction by agriculture. Tariffs should also be structured to complement tenure laws (e.g., taxation of fuelwood but with tax-breaks for fuelwood collected from managed woodlands approved by the Forest Service). The information gained from ATPRP impact and environmental monitoring should identify policies needing reform.

F2. Infrastructure Development and Nondevelopment

Destruction of important wildlife habitat can be reduced by strengthening the infrastructure of existing agricultural areas. Improved secondary roads, communications, markets, government support, and extension services in these areas would encourage agricultural intensification and production. This would reduce demand and slow expansion of agriculture in areas important to wildlife. Likewise, protecting areas important to wildlife from agricultural expansion by limiting infrastructure development would reduce habitat destruction. Road construction is a classic example of how to initiate habitat destruction.

F3. Institution Building

Agricultural chemicals are necessary to meet the demand for increased agricultural production. If used correctly, they could potentially reduce habitat destruction that would otherwise occur from expanding agriculture. If used badly, however, agricultural chemicals waste farmers' money—and more importantly—seriously pollute the rivers and lakes of Chad. Agricultural extension needs to accompany the marketing of agricultural inputs. It will be to the benefit of both the farmer and the environment.

Government agencies in charge of protecting the environment need support (e.g., park guards need weapons and equipment at least as good as those of poachers). Agencies should not have both extension and enforcement responsibilities (e.g., forest service could be strictly enforcement while agriculture services could extend forestry and agroforestry practices).

APPENDIX A-1
BIBLIOGRAPHY

Behrens, C.A., "The Scientific Basis for Shipibo Soil Classification and Land-use: Changes in Soil-Plant Associations with Cash Cropping," *American Anthropologist*, 91: pp. 83-100, 1989.

Blaikie, P. and H. Brookfield, *Land Degradation and Society*, Methuen & Co., New York, pp. 296, 1987.

Bocquier, G. and J. Barbery, *Notice explicative, Cartes pédologiques de reconnaissance au 1/200.000e*, Feuille Singako, ORSTOM, No. 32, Paris, 114, carte, 1968.

Bocquier, G., P. Audry, and J. Barbery, *Notice explicative, Cartes pédologiques de reconnaissance au 1/200.000e*, Feuille d'Am Dam, ORSTOM, No. 30, Paris, 102 pp., carte, 1968.

Bouteyre, G., *Etude pédologique de la ferme cotonnière de Youé (District de Fianga)*, Service de l'Agriculture du Tchad, Fort-Lamy, 39 pp. multigr., cart. 1/5.000e, 1955.

_____, *Reconnaissance pédologique de paysannats de la région du Logo Service de l'Agriculture du Tchad*, Fort-Lamy, 16 pp. multigr., cart. 1/20.000e, 1956.

_____, *Esquisse pédologique du Goz d'Am-Dam*, ORSTOM-CRT, Fort-Lamy, 30 pp. multigr., carte 1/100.000e, 1960.

_____, *Notice explicative, Cartes pédologiques de reconnaissance au 1/200.000e*, Feuilles de Koumra-Moundou, ORSTOM, No. 20, 110 pp. 2 cart., 1965.

Carmouze, J.-P., *Ions majeurs, phosates, et silicates dans le lac Tchad en avril 1968*, ORSTOM, Centre de Fort-Lamy, Cartes 1/1.000.000e, 18 pp., 1968.

Carmouze, J.-P. and G. Pedro, "Influence du climat sur le type de régulation saline du lac Tchad relations avec les modes de sédimentation lacustre," *Sci. Géol. Bull.*, 39(1): 33-49, 1977.

Charreau, C. and R. Nicou, "L'amélioration du profil cultural dans les sols sableux and sablo-argileux de la zone tropicale sèche Ouest Africaine et ses incidences agronomiques," *Agron. Trop.*, 26, 1971.

-76

Conkling, H.C., "An Ethnoecological Approach to Shifting Agriculture," *Environment and Cultural Behavior*, A.P. Vayda (ed.), The Natural History Press, New York, pp. 221-233, 1969.

Gilruth, P.T. and C.F. Hutchinson, "Assessing Deforestation in the Guinea Highlands of West Africa Using Remote Sensing, *Photogrammetric Engineering and Remote Sensing*," 56(10), pp. 1375-1382, 1990.

Guichard, E., *Etude pédologique de la région inter-Logone, dépression de Fianga*, ORSTOM-CSLT, Fort-Lamy, 26 pp. multigr., 1 carte au 1/200.000e, 1957.

_____, *Etude pédologique de la zone Loka-Kabia*, ORSTOM-CRT, Fort-Lamy, 104 pp. multigr. 3 cart., 1960.

_____, *Note sur les prélèvements pédologiques à Tikem et Daoua*, ORSTOM-CRT, 19 pp., 1 carte multigr., 1962.

Guichard, E. and J. Barbery, *Etude pédologique de la zone Eré-Loka*, ORSTOM-CRT, Fort-Lamy, 176 pp. multigr. Résult. Analyt. 67 pp. multigr., 4 cart., 1960.

Guichard, E. and P. Poisot, *Etude pédologique de la zone Satégui-Déressia*, ORSTOM-CRT, Fort-Lamy, 100 pp. multigr., 5 cart., 1961.

_____, *Notice explicative, Cartes pédologiques de reconnaissance au 1/200.000e*, Feuille de Melfi, ORSTOM, No. 19, Paris, 85 pp. carte, 1964.

Hunn, E., "The Utilitarian Factor in Folk Biological Classification," *American Anthropologist*, 84, pp. 830-847, 1982.

Jacques-Felix, H., "La vie et la mort du lac Tchad," S.T.A.T., *Bull. agron.*, No. 3, 96 pp., 1947.

Jones, M.J. and A. Wild, *Soils of the West African Savanna*, Commonwealth Agricultural Bureaux, England, 1975.

King, J.W., "Analysis of Production Potential and Maintenance of Production for Selected Irrigable Soils by the Chari River in the Sahel Region of Chad," Ph.D. thesis, Cornell University, Ithaca, New York, pp. 152, 1980.

Kusnir, I., *Géologie, ressources minérales et ressources en eau du Tchad*, Centre National d'Appui à la Recherche, N'Djaména, 100 pp., carte 1/4.000.000e, 1993.

de Lannoy, M., "Inventaire des ouadis du Kanem," rapport d'etude et cartes 1/200.000, Centre de Teledection, FAO, 1991.

Lepoutre, B., "Etude pédologique de berges du Chari entre Fort-Lamy et Mani (côté Tchad)," Service de l'Agriculture du Tchad, 10 pp. multigr. carte, 1952.

Marius, C., *Notice explicative, Cartes pédologiques de reconnaissance au 1/200.000e*, Feuille de Dagéla, ORSTOM, No. 17, Paris, 47 pp., carte, 1964.

Marius, C. and J. Barbery, *Notice explicative, Cartes pédologiques de reconnaissance au 1/200.000e*, Feuille de Fort-Archambault, ORSTOM, No. 29, 40 pp., carte, 1964.

Marsh, S.E., J.L. Walsh, and C.F. Hutchinson, "Development of an Agricultural Land-use GIS for Senegal Derived from Multispectral Video and Photographic Data," *Photogrammetric Engineering and Remote Sensing*, 56(3): 351-357, 1990.

Perroux, K.M. and I. White, "Designs for Disc Permeameters," *Soil Sci. Soc. Am. J.*, 52: pp. 1205-1215, 1988.

Pias J. and P. Poisot, *Notice explicative, Cartes pédologiques de reconnaissance au 1/200.000e*, Feuilles de Bokoro-Guéra-Mongo, ORSTOM, No. 16, Paris, 146 pp., 3 cart., h.t., 1964.

_____, *Notice explicative, Cartes pédologiques de reconnaissance au 1/200.000e*, Feuilles de Abou-Déia, Mangalmé, ORSTOM, No. 28, Paris, 118 pp., 2 cart. h.t., 1967.

Pias, J., *Les sols du Moyen et Bas Logone du Bas Chari, des régions riveraines du lac Tchad et du Bahr el Ghazal*, Mém. ORSTOM No. 2, Paris, 438 pp., 8 cartes 1/200,000e, 5 cartes 1/100.000e, 2 cartes 1/1.000.000e, 1962.

_____, Notice explicative, Cartes pédologiques de reconnaissance au 1/200.000e, Feuilles d'Abéché, Biltine, Oum Hadjer, ORSTOM, No. 13, Paris, 105 pp., 3 cart., h.t., 1964a.

_____, *Notice explicative, Cartes pédologiques de reconnaissance au 1/200.000e*, Feuilles de Fort-Lamy, Massénya, Mogroum, ORSTOM, No. 14, Paris, 103 pp., 3 cart. h.t., 1964b.

_____, *La végétation du Tchad: Ses rapports avec les sols, Variations paléobotaniques au quaternaire récent*, ORSTOM S.S.C. Bondy, 45 pp. multigr., graph., cart. 1/1.500.000e, 1968a.

_____, *Notice explicative No. 41, Cartes pédologiques du Tchad à 1/1.000.000*, Vols. I and II, ORSTOM, Paris, 1970.

_____, *Contribution á l'étude de formations sédimentaires tertiaires et quaternaires de la cuvette tchadienne et des soils qui en dérivent* (République du Tchad), ORSTOM. S.S.C. Bondy, 425 pp. multigr., graph., 2 cart. 1/1.000.000e, 1968b.

Pias, J. and J. Barbery, *Etude du périmètre de reboisement d'El Amadji*, ORSTOM-CRT, Fort-Lamy, 29 pp. multigr., carte 1/10.000e, 1960a.

_____, *Evolution de la salinité dans le polder de Bol Guini en 1959 et 1960*, ORSTOM-CRT, Fort-Lamy, I: 108 pp. multigr., II: Résult. analyt., 68 pp. multigr., 5 cart. 1/10.000e, graph, 1960b.

_____, Etude pédologique du Ranch de l'Ouadi Rimé, ORSTOM-CRT, Fort-Lamy, 113 pp. multigr., 3 cart. au 1/50.000e, 1961.

_____, Etude pédologique du Ranch de l'Ouadi Rimé (partie nord du Ranch). ORSTOM-CRT, Fort-Lamy, 73 pp. multigr., 5 cart., 2 graph, 1962.

_____, *Notice explicative, Cartes pédologiques de reconnaissance au 1/200.000e*, Feuille de Miltou, ORSTOM, No. 15, Paris, 69 pp. carte h.t., 1964.

_____, *Notice explicative, Cartes pédologiques de reconnaissance au 1/200.000e*, Feuilles Lac Iro-Djouna, ORSTOM, No. 25, Paris, 98 pp. 2 cart. h.t., 1965.

Pias, J. and P. Poisot, *Sols de la palmeraie de Largeau*, ORSTOM-CRT, Fort-Lamy, 71 pp. multigr., 2 graph., carte 1/100.000e, 1962.

Pieri, C., *Fertilité des terres de savanes*, Ministère de la Coopération et CIRAD-IRAT, Paris, 444 pp., 1989.

Tabor, J.A., "Ethnopedological Surveys: Soil Surveys that Incorporate Local Systems of Land Classification," *Soil Survey Horizons*, 33(1):1-5, 1992.

Tabor, J.A., A. Watson, A. Diagne, M. Daffe, M. Dieme, and M. Khouma, "Annex du sols, Plan directeur de développement de la Haute Vallée du Fleuve Sénégal, Organisation pour la Mise en Valeur du fleuve Sénégal," Dakar/USAID/Dames & Moore, Paris, pp. 91, database on diskettes, 1:50,000 and 1:20,000 maps, 1993.

Warshall, P. (ed.), J. Kindler, E.J. Arnould, C.F. Hutchinson, and R. Varady, *The Lake Chad Conventional Basin: A Diagnostic Study of Environmental Degradation*, University of Arizona, UNSO, and UNEP, 182 pp., 1989.

ANNEX B

RANGELAND RESOURCES

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Consultant/Chemonics

ANNEX B
RANGELAND RESOURCES

The objective of this annex is to briefly describe Chad's rangeland resources, identify how changing cultivation practices influence them, make recommendations for monitoring the changes, and determine what impact ATPRP policy reforms might have in this regard. The annex will also recommend mitigation measures to compensate for negative impact the program might have.

Four regions of Chad will be affected by ATPRP policy reform: five prefectures in the southwestern part of the country, the recessional sorghum production in Salamat, the wadi agricultural production in Kanem and Lac (considered important surplus agriculture production regions), and the vegetable production projects in a limited number of wadis near Abéché. (See Map 1 on page III-3 of the main report).

Rangeland resources described in this annex are applicable only to the southwest region of Chad, and the thoughts concerning ATPRP's impact apply where agriculturalists practice a rotational fallow system or extensive cultivation techniques. The monitoring techniques are applicable to all ecosystems. This annex does not consider Kanem, small vegetable plots in the wadi areas, or the agriculture activities south of Lake Chad. It was impossible to travel in Kanem and north of Lake Chad because of civil unrest in the area; nor was the team able to look at the Salamat. The vegetable projects near Abéché were looked at and the ecosystems of the region were reviewed; the five prefectures in the southwestern region were also visited and reviewed.

This annex also includes an appendix, Field Trip Observations, containing a stratified plant species lists and other physical information concerning ecosystems in the two regions.

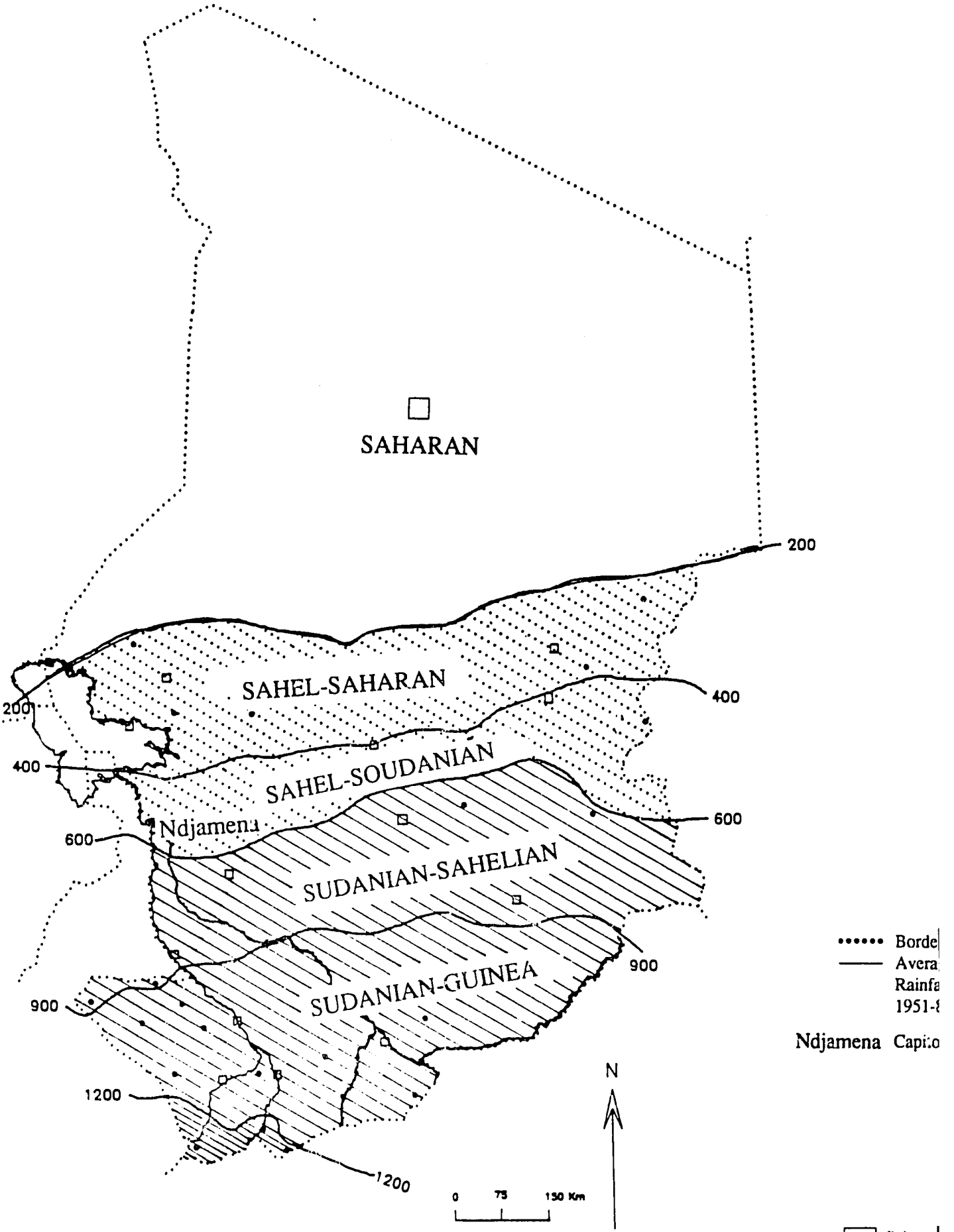
A. Rangelands: Descriptions and Use

Rangelands in Chad consist of non-tenured forests, bushland savannahs, grasslands, fallows, and harvested cultivated fields where herders find water, grazing, and bed-grounds for their livestock. Rangelands can be used by any animal herd or flock, regardless of origin. Cultivated fields have tenure when they are occupied with unharvested crops and herders have the responsibility of keeping their animals from damaging the crop. If crops are infringed upon by animals the owner or herder is generally responsible for paying crop farmer restitution for losses. Once the crop is harvested, the field again becomes rangeland.

A1. Bioclimatic Zones

Chad has four bioclimatic zones (see Map B-1 on the following page):

Map B-1: Bioclimatic Zones of Chad



Hamel 1988

The Saharan Zone is desert with up to 200 mm of rainfall. Soils are unstable and unproductive except for irrigated vegetable gardens and date groves growing in wadis. The sparse human population is largely nomadic, with some livestock, mostly small ruminants and camels.

The Sahelian Zone receives unreliable rainfall of 200-600 mm. In good rainfall years the poor soils will support subsistence rainfed cereals (mostly millet) and some rainfed and irrigated vegetables; drought conditions persist, however, causing regular food deficits. Livestock production is the most important economic activity.

The Sudanian Zone has dependable rainfall between May and September of 600-1,000 mm, and produces a surplus of coarse grains, cassava, cotton (commercial), and fruits. It has a dense human population with increasing numbers of sedentary small ruminants and cattle. Large numbers of transhumant and nomadic cattle herds use the zone during the dry season.

The true Guinea Zone in the tip of southwestern Chad has dependable rainfall from May-October (1,000-1,200 mm). It produces coarse grains, cassava, cotton (commercial), and fruits. Raising cattle and small ruminants has become more popular in recent years. Nomadic and transhumant herds also use the zone during the dry season.

More distinct separations among the bioclimatic zones existing 30 years ago now appear as gradual vegetative change occurring over distances of 100 km or more, with influences of the drier northern zones moving south. Thus terms such as Saharan-Sahelian Zone, Sahelian-Sudanian Zone, and the Sudanian-Guinea Zone are now commonly used.

A2. Vegetative Types

Vegetation studies covering most of the agricultural production target area are dated. Documentation prepared by I.E.M.V.T. (Gaston et al., 1979) identifies vegetation types in the Lake Chad watershed, identified by soil type and major plant species in the herbaceous and woody strata. The accompanying small-scale map (1:1,000,000) shows the vegetation types in different colors, and has a matching color-coded table, giving the soil type and listing a few of the major plant species. The only country-wide study, *La Végétation du Tchad* (Pias 1970), is a broad overview of soil and related major plant species, but lacks plant species detail, and the map scale is too small (1:1,500,000) for site-specific studies.

Broadleaf shrubby savannah. What was once described as a forest-tree-savannah, observed in the Sarh area, with a 15 m canopy of *Isoberlina doka, Anogeissus leiocarpus, Terminalia laxifolia, Pterocarpus lucens,* and *Daniellia oliveri* has, through continual slashing and burning, become a broadleaf shrubby savannah predominated by cultivated/ fallow associations with an occasional tree over 10 m high. *Borassus aethiopum* (Rhum Palm-Ronier) once was abundant in the deeper sandy soils with high water table, but has become an endangered species. The Rhum Palm, known as "ironwood" because of its strength and resistance to termites, has been extensively harvested for building purposes.

Many of the remaining larger trees occur in cultivated fields surrounding villages. It is here that stands (parks) remain of fruit and other utilitarian trees such as Mango *(Mangifera indica)*, Néré *(Parkia biglabosa)*, Shéa butter tree *(Vitellaria paradoxa)*, *Acacia albida*, and an occasional Tamarind tree *(Tamarindus indica)*, species that survived because they provide needed products in the village. They are protected species. Two species found in every vegetative type are the Doum Palm *(Hyphaene thebaica)* and the Desert Date *(Balanites aegyptiaca)*.

Important bunch grasses for grazing and thatching purposes—*Andropogon gayanus*, *Hyparrhenia rufa*, and other *Hyparrhenia spp.*, and, to a lesser degree *Diheteropogon amplectens*—also occur in this vegetative type. Annual grasses commonly found are *Chloris pilosa*, *Ctenium spp.*, *Dactyloctenium aegyptiacum*, *Echinochloa colona*, *Eragrostis tremula*, *Panicum laetum*, *Pennesetum pedicilatum*, *Schoenefeldia gracilis*, and *Setaria pallide-fusca*.

Grassland floodplain. An example of a vegetation type under pressure from livestock and cultivation is the grassland plain along the Logone River. It is predominantly perennial grass cover of *Hyparrhenia rufa*, *Elytrophorus spicatus*, *Vetiveria nigritana*, and grasses such as *Panicum anabaptistum*, other *Panicum spp.*, *Loudetia simplex*, *Sporobolus sp.*, and *Eragrostis spp.*, which occur in disturbed or cultivated areas. Forbs *Hydrolea floribunda* and *Ammania auriculata* are also found. Another flood plain providing dry season forage and water is the Mayo Kebbi River between Léré, Fianga, and Buibi, where a more typical marsh vegetation exists. *Mimosa pigra*, *Sesbania sesban*, and *Salix sp.* are dominant shrubs, while *Hyparrhenia rufa*, *Eragrostis atrovirens*, *Cyperaceaes*, *Vetiveria nigritana*, *Panicum sublaetum*, *P. anabaptistum*, *Paspalum orbiculare*, and *Chloris robusta* form the majority of herbaceous cover.

These flood plains are distinguishable by their lack of woody species. More and more their surfaces are being converted into recessional fields of white sorghum (Bérbéré), corn, red sorghum, taro (cocoyam), rainy season and irrigated rice, and vegetable gardens. Bérbéré, rice, and taro were still being cultivated in mid-March, restricting livestock to alley-ways of forage and drinking points along the Mayo Kebbi. In the future these areas will be in danger of being cultivated extensively, even further limiting access by livestock.

Upland forest-shrub savannah. The upland forest-shrub savannah occurring from Kélo west towards Léré is marginal agricultural land scattered between rocky eroded hills. Soils are shallow and infertile, requiring farmers to frequently change field locations. Fallows of one or two years are common (see appendix). Cotton and pénicillaire (millet) are the common crops, and the area is also an important grazing area for livestock during the rainy season. The ecosystem is comprised of fire-tolerant plant species; the dry annual grasses provide adequate fuel to carry hot bushfires during the late dry season (February and March). Perennial grasses are *Andropogon gayanus*, *Hyparrhenia rufa*, and other *H. spp.*, but the annual grasses like *Ctenium sp.*, *Loudetia annua*, *Diheteropogon amplectans*, *Chloris spp.*, *Dactyloctenium aegyptiacum*, and *Pennesetum pedicilatum* predominate. Rainwater accumulates in depressions and excavation pits along the highway, providing surface livestock water into January and February.

A3. Vegetative Associations

The vegetative types described by I.E.M.V.T. (Gaston, 1979) correlated with vegetation associations observed in the field. Degradation was evident in every type, but particularly in forest types where cultivation and extensive fallow systems were functioning. Observed plant species were recorded along the primary road system between the major towns in the five southwestern prefectures, between N'Djaména and Hadjer el Hamis, N'Djamena and Guelengdeng, and Abéché-Mongo-Arboutchatak. Following the field trip, the species lists were stratified into vegetative associations for a particular segment of the trip. The areas covered were those most impacted by the ATPRP. (See appendix.)

A4. Human Density and Distribution

Discounting the largely urban population of the prefecture of Chari Baguirmi, the other five prefectures of the southwestern region make up 48 percent of Chad's population, which in 1991 was estimated to be 5,819,000 persons *(Statistique 1991)*. This represents a population density of 22 persons per km^2 versus 2.6 persons per km^2 for the rest of the country (See Table 1 below). It is unclear whether this figure includes migrants such as livestock herders and their families, emigrants from neighboring countries, and north-to-south movement resulting from drought or other causes, many of whom have become permanent residents of the region. The new national census, carried out in April 1993, should provide more reliable data.

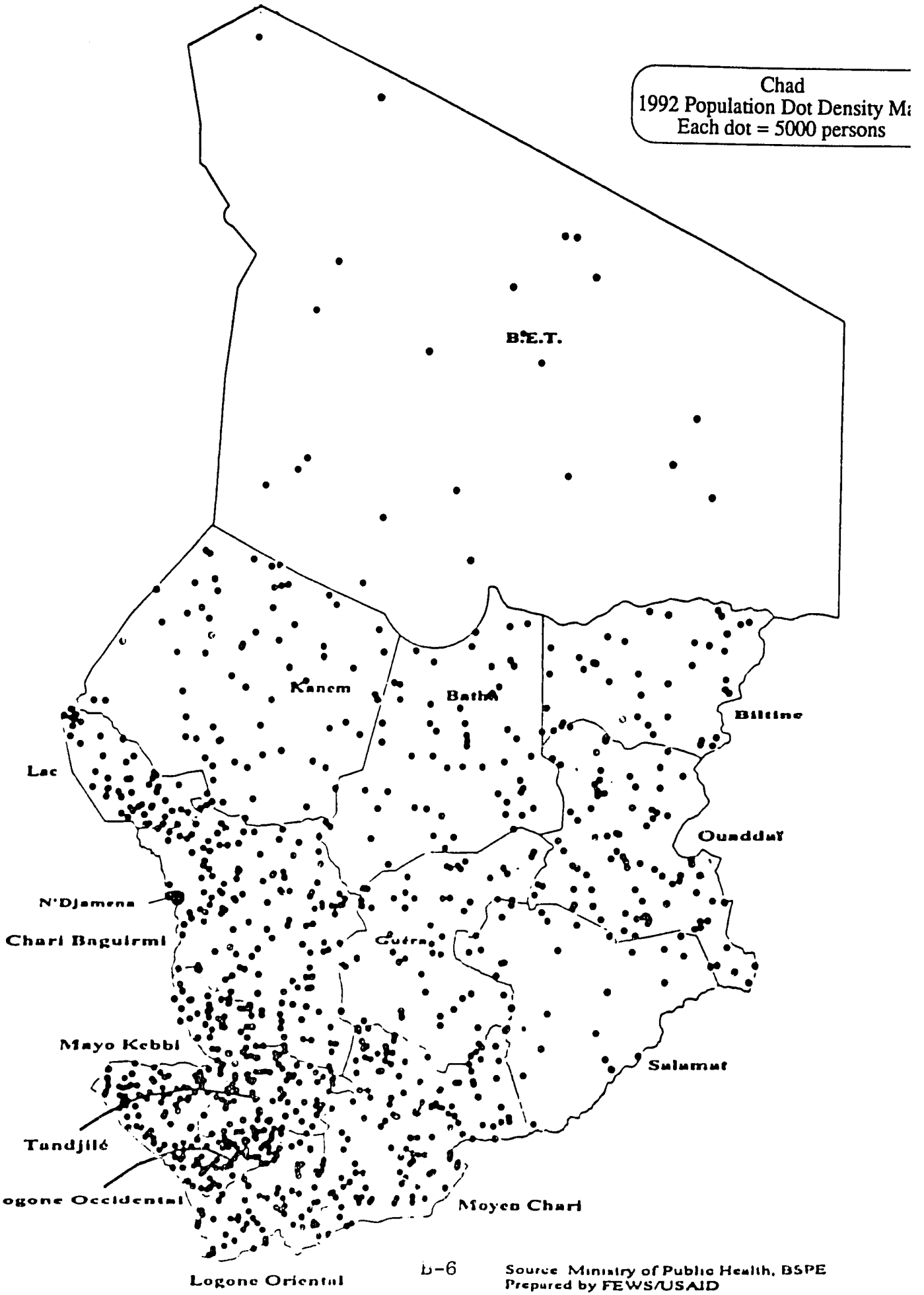
TABLE 1: Human Population

Prefecture	1991 Population	Area in km^2	Density/km^2
Mayo-Kebbi	919,400	30,105	15 persons
Moyen-Chari	692,100	45,180	15 "
Logone Oriental	407,300	28,035	15 "
Logone Occidental	389,900	7,695	38 "
Tandjile	395,700	18,045	22 "
Region Total	2,804,400	129,060	22 persons
Other Total	3,014,600	1,154,920	2.6 persons
Chad Total	5,819,000	1,283,980	4.5 persons

Source: *Statistique 1991*

(See also Map B-2, Human Density, found on the following page.)

Map B-2: Human Density



Source Ministry of Public Health, BSPE
Prepared by FEWS/USAID

A5. Livestock Ownership and Herding Practices

A5a. Sedentary Livestock

Cotton farmers initially started purchasing draft oxen in the late 1960s (personal accounts) and today 90 percent of the cotton farmers are reported using animal traction (Shar, 1992). The use of animal traction has allowed the individual farmer to extend his fields and improve cultivation efficiency. Interviews with a number of farmers (March 1993) in the Moyen Chari and Logone Occidental prefectures indicated that profits from the sale of cotton and excess grains are sometimes used to purchase additional oxen.

TABLE 2: 1987 Animal Traction Oxen

Prefecture	Numbers	Net 5 Year Gain	
Mayo-Kebbi	38,960	+39%	1982-'85, and 1987
Moyen-Chari	42,220	+26%	" "
Logone Oriental	21,600	+20%	" "
Logone Occidental	15,770	+26%	"
Tandjile	28,930	+28%	" "

Source: *ONDR (Statistique 1991)*

Census information for livestock and animal traction oxen has been recorded for many years. In the early years, the annual cattle census was based on the rinderpest vaccination campaigns, but in recent times civil unrest and lack of resources have made it impossible to obtain accurate census figures, so the previous year's data have simply been increased by a standard two percent annually. It is unclear whether the livestock census includes transhumant populations and animal traction oxen. The livestock census is the responsibility of the Livestock and Veterinary Service (DESV) while the animal traction figures come from the National Office of Rural Development (ONDR).

Indications are that sedentary farmers are investing in new oxen, young bulls, and even breeding cows. Goats and a few sheep are also evident in almost every village in the region (see Tables 2 and 3 below). CARE's village projects in the Moyen Chari prefecture have collected livestock numbers: four villages reported having an average of 300 goats, 41 sheep, and 109 oxen each; each village averaged 734 inhabitants (CARE, Sarh 1992). Animal numbers are increasing in the five southwest prefectures, but to what degree will be speculation until an adequate census can be taken.

TABLE 3: 1991 Livestock Population Estimates

	Mayo-K	Moyen-C	L-Orient.	L-Occid.	Tandjile
Cattle	106,906	474,952	72,243	71,465	53,586
Sheep/goats	506,894	173,916	161,524	136,639	127,710
Camels	no info	no info	no info	no info	no info
Donkeys	12,016	no info	no info	no info	no info
Horses	1,877	4,060	6,242	5,151	10,521
Pork	6,395	2,814	1,218	1,439	1,439

Source: Department of Livestock and Veterinary Services (DESV) *(Statistique 1991)*

To what extent sedentary livestock are competing with transhumant livestock for land, water, and feed is unknown. The answer depends on the location of sedentary livestock in relation to the dry season rangelands and water sources, and whether or not they transhume. Competition among livestock of different origins for rangeland resources could contribute to environmental degradation.

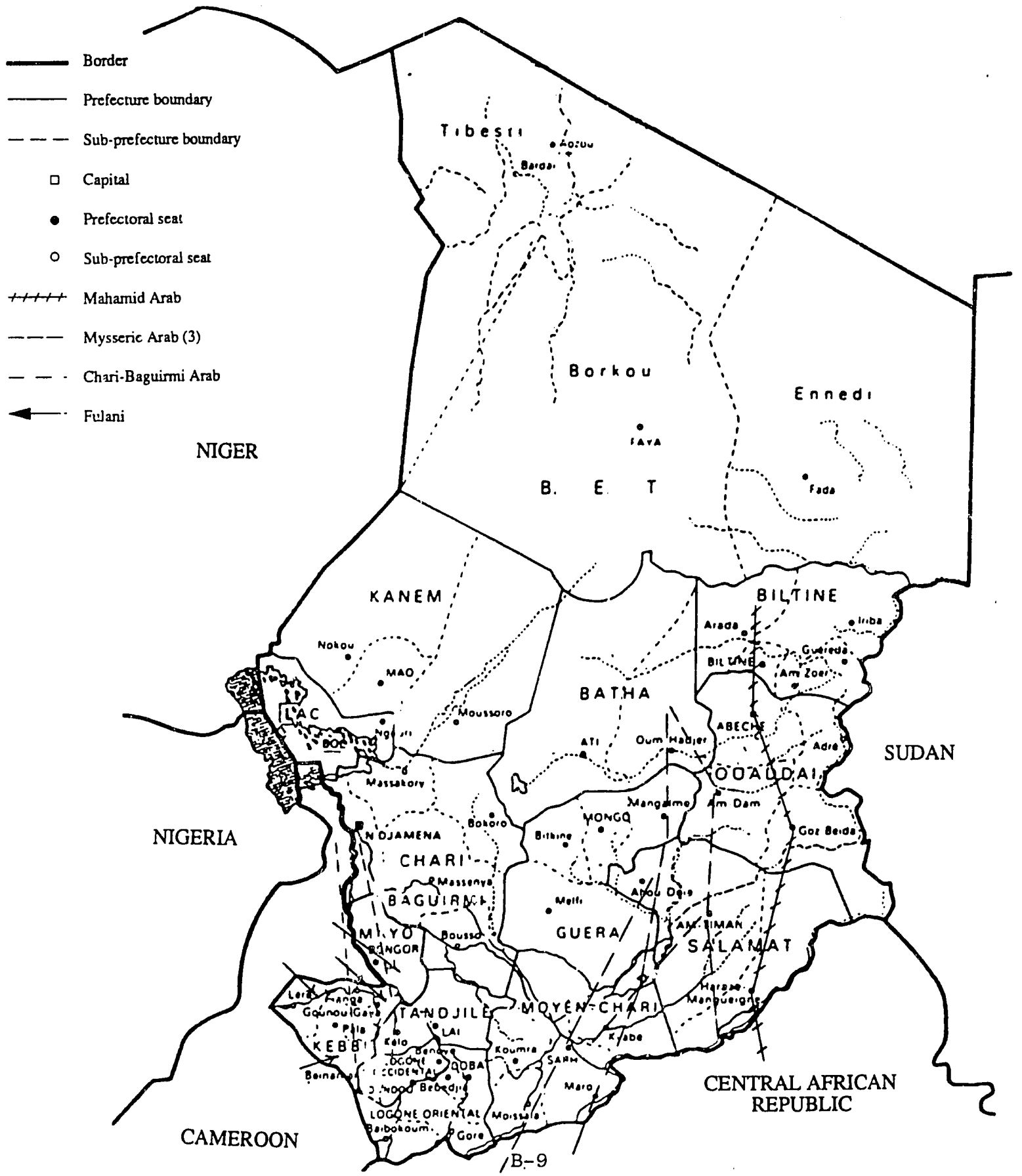
A5b. Transhumant Herds

Herds of cattle and flocks of sheep from the northern prefectures transhume south following the rains, and the reverse movement starts at the beginning of the rains in the south (See Map B-3, Transhumant Corridors, found on the following page). Because of the increased uncertainty of receiving adequate rainfall in the Sahel, both farmers and herders have moved south to survive. Indications are that some nomadic herds have become permanent residents of the Sudanian zone and transhume within the zone to avoid conflict with hostile sedentary crop farmers.

Mahamid Arabs from Biltine prefecture descend gradually south through Ouaddaï and Salamat, with some herds going into the Central African Republic (CAR). The Mysserie Arabs of the Batha Prefecture head south via three slightly different itineraries, some passing through Ouaddaï and Salamat into CAR, and the others passing south through Guéra and Moyen-Chari with slightly different routes. Some of these pass in the vicinity of Sarh and others go east of Sarh descending as far as the CAR *(Suivi, 1992)*. The Chari-Baguirmi Arabs descend south along the flood plains of the Logone River towards Bongor (Mayo-Kebbi) and points south, while Fulani herders from Cameroon cross into Mayo-Kebbi and other parts of the region in search of dry season pasturing.

Also observed while travelling through the region (March 1993) were several herds of nomadic N'Bororo cattle (also known as red Fulani). The breed originated from central Niger and the Sokoto providence of Nigeria. These tall, long-horned animals of reddish-brown color roam over much of central and west Africa from the Sahara to the rainforests (Carter and McLeroy, 1968).

Map B-3: Transhumant Corridors



A5c. Marketing Routes

Commercial cattle herds and small ruminant flocks travel by foot across Chad specifically for the livestock market in N'Djaména, and for live export to Nigeria, Cameroon, and to a much lesser degree to the CAR *(Statistique 1991)*. Most exportation of live animals is done clandestinely, since the many taxes and fees imposed on animals destined for export markets amount to more than 30 percent of the live value of the animal, not counting the additional payment of bribes here and there along the route and various fees levied when entering neighboring countries (Interview DESV, February 1993).

Passage of live animals through the southwestern corner of Chad for markets in CAR, Cameroon, and Nigeria is well recorded (Carter and McLeroy, 1968, and *Suivi*, 1992). The environmental impact of these passing herds and flocks is measurable. Herders cut tree limbs and shrubs to feed animals during the drier months and herds linger in rangelands for several days awaiting border passage or resting.

A5d. Livestock Projects

Only one regional livestock project exists in the southwestern prefectures of Chad. FAC (French Fonds de l'Aide et de la Coopération) is financing the *Groupement de Défense Sanitaire*, basically a program of providing health care to traction oxen. This has no impact on the environment.

(See Map B-4, Livestock Project Zones, found on the following page.)

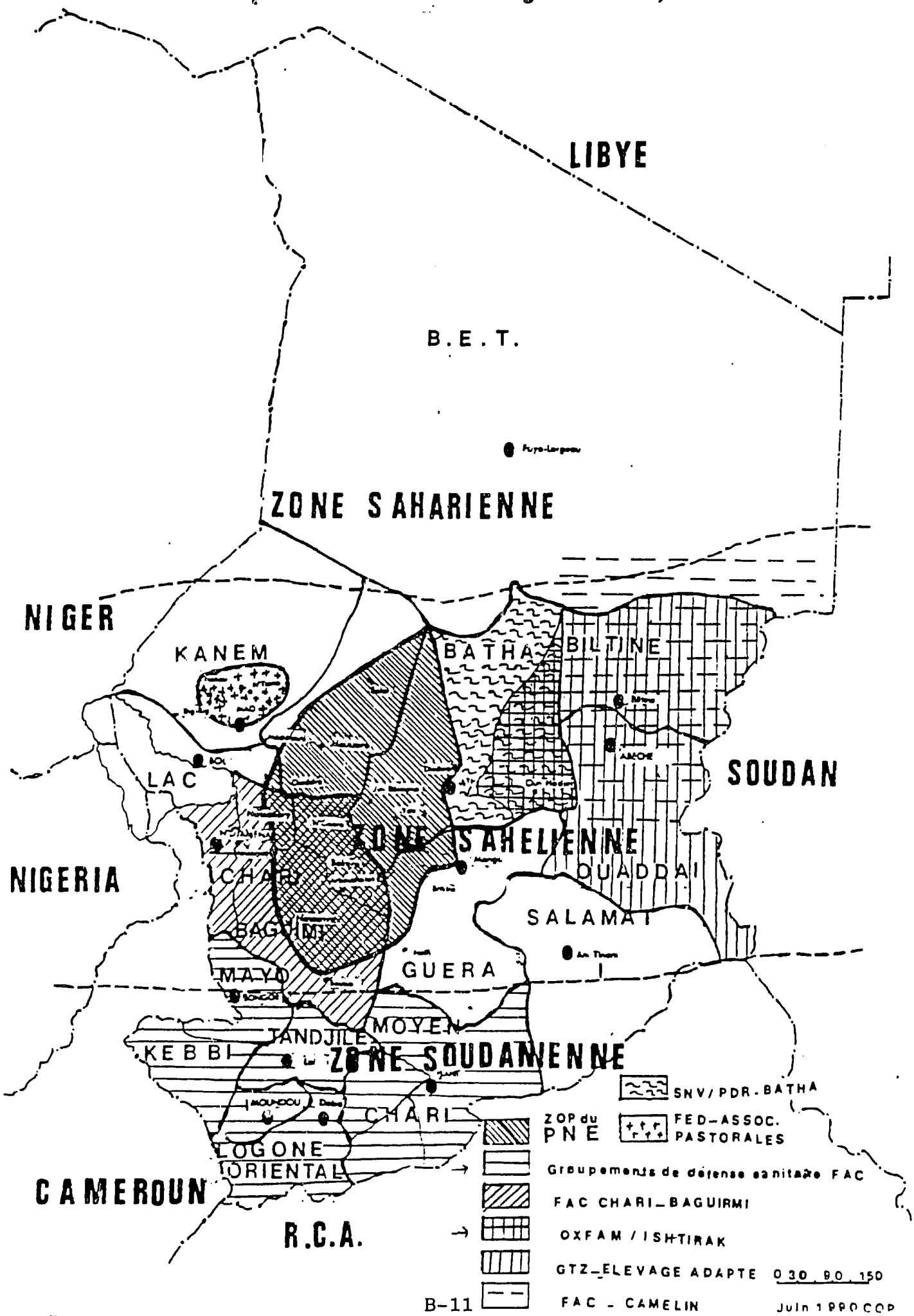
A6. Agricultural Influences and Conflicts

A6a. Crop Residues

Farmers cut and carry crop residues, such as peanut hay, sorghum and pénicillaire stalks, and dry grasses, to village compounds and store the material on platforms. These materials are used late in the dry season for prized animals, milk cows, horses, or for finishing sheep for holidays. In the south, stored crop residues primarily feed draft oxen prior to and into the early plowing season during April and May.

Removal of crop residues and dry grass from fields and rangeland essentially removes biomass that would be grazed by roaming livestock or later burned by wildfire. Unused crop residue stalks left in fields are gathered before the rainy season and burned. The tradeoff between soil covering provided by the biomass and the fact that it is all eventually burned anyway implies that the most useful thing to do is to cut and carry; there is little measurable negative environmental impact from cutting and carrying residues. The removal of dry grass from soil surfaces whether by fire or cut and carry is detrimental to the environment.

Map B-4: Livestock Project Zones, Chad



A6b. Woven Matting

Matting is woven from *Hyphaene thebaica* (Doum Palm). Harvesting is systematically managed, usually from large areas of sprouting leafy seedlings. The activity provides income and has no negative environmental impact. The species also contains medicinal, fruits, and wood properties.

Woody forms of Doum Palms are becoming very rare in some areas, such as south of N'Djamena, near Lake Chad, and from Mongo to Abéché. The absence of woody forms of the species is alarming. It, as well as the equally important Rhum Palm *(Borassus aethiopum)*, should be on the endangered species list. Propagation and management of these species should be encouraged.

A6c. Thatching

Thatching straw is collected from *Hyparrhenia rufa*, other *Hyparrhenia spp.*, and *Andropogon gayanus* perennial bunch grasses, which usually occur in pure stands along major waterways or seasonally flooded grass plains. Harvesting and storage occur early, before ignition of bushfires. Both the harvesting of straw and the bushfires are beneficial because they open up the thick stands, permitting exposure of leafy basal area to direct sunlight. The combination of exposure and the retention of recessional soil moisture allows the plant to develop green leaves and enlarge. The same species are grazed by livestock when leaf material is green or drying. Without the influence of agriculture these natural grasslands are managed well by livestock users, providing dry season feed for their cattle. Income is generated through collection of thatching material. Little environmental impact results from this activity.

A6d. Farmer vs. Herder Conflict

Farmers view transhumant herders as "pests" because they allow their livestock to eat field crops and rob farmers' granaries (Farmer interviews, March 1993). Conflicts between sedentary farmers and transhumant herdsmen have sometimes been violent, even involving loss of life.

Exceptions do exist where transhumant herders have used the same seasonal pastures for many years, and have built up a good rapport with the crop farmer, often by fertilizing fields and providing milk to local consumers. When crops are damaged by livestock under these conditions, herdsmen almost always make restitution. An example is in the Léré region, where Fulani from Cameroon and other parts of Mayo Kebbi prefecture have traditionally shared rangelands and water sources with local Moundang herders. A vegetable farmer near Abéché, discussing conflicts with herders, said that livestock have gotten into his irrigated plots and eaten plants, but that the herder paid the damage and promised never to return. He also said that farmers in the area will often pay herders to bed their animals on next year's millet fields, leaving deposits of dung to fertilize the field.

A7. Water

Water for grazing animals comes mainly from permanent surface waters like the Chari River and its tributaries, the Logone River and its tributaries, the Mayo Kebbi, and Lakes Léré and Fianga. Inundated depressions and recessional flood plains are also used for livestock watering. Village animals are watered from village wells when surface water is not available.

Agricultural chemicals contaminating watering sources could enter the food chain if consumed by livestock, but would have to be sufficiently toxic to kill large ruminants outright.

A8. Conclusions

When comparing the abundant available environmental resources of the five southwest prefectures with other regions of Chad, and with the resources of neighboring countries, one can see why the human population density is high. Reliable rainfall, abundant and equitable distribution of surface waters, diversity of cultivable lands and crops, and adequate source of heating fuel and construction material are factors contributing to the popularity of the region.

With few exceptions, the region appears to have plenty of land available for farming. One exception is Moundou and north beyond the airport to Mbala, Benoy, and Doher. This area is highly populated and has limited fertile agriculture lands. Forests are degraded and the women have to look for firewood up to 15 km away.

The combination of increased spatial occupancy by a fixed human population, a mobile herding system, and extensification of agriculture, has caused traditional transhumants to modify their historical trekking routes, and to relocate their seasonal camps. Much of what was once rangeland has been, or is now, under cultivation. The remaining land areas are occupied by increasing numbers of resident animals plus the transhumant herds forced to move in from traditional camps in other parts of the region. The nomadic herding system is breaking down and giving way to confusion. Traditional chiefs no longer have the power to control political and physical environments up to a thousand km distant. Herders are looking for dry season rangelands for their herds, no matter what. Traditional ways have fallen by the wayside; herders tend to just get what they can and move on.

B. Impact of ATPRP

B1. Extensification of Agriculture

Extensification increases land degradation by removing plant species and upsetting the ecosystem. This increases pressure on adjacent land from livestock seeking new grazing areas and more accessible watering points, birds and wild animals being forced to find new habitats, and humans harvesting fruits, firewood, and weaving materials being forced to look other places. Extensification of agriculture has already degraded forest ecosystems in Chad. Continual slashing and burning of forests to establish cultivated fields has destroyed or

greatly decreased many of the forest species (Hamel et al., 1988). The unique grassland ecosystems of the Plain of Lai and other plain areas along the Logone River, as well as the plains along the Mayo Kebbi, are presently subject to intensive agriculture that could very easily be expanded as a result of ATPRP.

The Plain of Lai and the receding marsh of the Mayo Kebbi are prime areas for extensification. The impact of extensive agriculture on these ecosystems would be devastating. The Plain of Lai is in part cultivated by rainfed, recessional, and limited irrigated cropping. The majority of plant cover remains a fire climax perennial grassland type predominately *Hyperrhenia rufa*, other *H. spp.*, *Vetivaria nigritana*, and individual plants of *Elytropphorus spicatus*. Forbs *Hydrolea floribunda* and *Ammania auriculata*, and Cyperaceaes (carexes and sedges) also occur. Once the soil is disturbed, the *Hyperrhenia spp.* disappear, being replaced by Cyperaceaes, *Panicum spp.*, *Paspalum orbiculare*, *Chloris robusta*, and *Vetivaria nigritana*.

Parts of the Mayo Kebbi drainage, between Lake Fianga and Lake Léré, are no longer in a natural vegetation stage because of the intrusion of cultivation. The area cultivated has increased and production intensified to the point where three to four different crops a season are grown on the same parcel of land. At one time the fire climax (sub-climax) perennial bunchgrass dominated this recessional flood plain, but gradually, the highly productive perennial grassland cover has been replaced by a degraded secondary ecosystem that produces less thatching material and significantly less grazing biomass. Once the natural vegetation is destroyed by cultivation, it returns very slowly if ever.

B2. Intensification of Agriculture

In Chad it is rare to find any ecosystem not influenced by the combination of cultivation, fire, grazing, and wood harvesting. Farmers living in less densely settled regions have established more than one cultivated area, but because of labor shortages they cannot farm more than one field. In this case, land once cultivated may be left to fallow. Fallows of 10-20 years are known, but in this region of Chad it is rare to see fallow areas older than five years. The older the fallow, the more mature and dense the woody vegetation becomes, and the less it resembles a fallow vegetative type. Livestock graze fallow areas year round, but they are particularly important during the cropping season. Re-establishing agriculture in mature fallow areas destroys the secondary plant ecosystems, thus destroying habitats of wood harvesters, grazing animals, birds, and other wildlife.

Farmers in densly populated areas may be forced to use the same farmland year after year without the opportunity of a rest rotation fallow system. One area in the prefecture of Logone Occidental, the region around Moundou and north through Mbata, Benoy and Doher, is so deficient in land that farmers are forced to cultivate the same fields season after season. Fields are abandoned as they become unproductive.

The environmental impact of intensive agriculture is to destroy fragile secondary vegetation types on fallow lands. When cultivation is resumed on fallow lands, sedentary grazing animals are forced to search for new rainy season pastures. This means that animals

go farther and farther from the village and start competing for resources within the common grounds between villages. In addition, women and children are forced to search farther for wood products, competing with other villages for the same products.

The impact on rangeland resources attributed to micro-irrigated and recessional garden areas along seasonal flood plains and in wadis would be difficult to detect.

C. Monitoring

C1. First Year Monitoring

The first year of monitoring should establish basic information:

Select representative villages. Within each major vegetative type, select a representative village involved in growing a diversity of agricultural crops. It may be possible to monitor more than one cropping system in the same site. The following vegetative types are recommended for monitoring purposes:

- flood plain vegetation with recessional cropping
- flood plain vegetation with rainfed cropping
- flood plain vegetation with irrigated (garden) cropping
- upland bush savannah with upland rainfed cropping
- and forest savannah with rainfed cropping

Identify village territory. Identify, through village leadership and simplistic systematic interviews, the land-use boundary or "village territory" (VT). Determine and locate land-use within the VT: living space, agricultural fields (both fallow and actively cultivated), pastures, dead lands (bare soil and roads), lands used for collecting firewood and other forest crops, and "common lands" that may be used by more than one village.

Determine VT boundaries on the ground and draw them on 1:50,000 scale maps (available with Chadian Government permission from Institut Géographique National, Paris). The procedure for obtaining maps from IGN is lengthy, and some maps of the series are no longer available. The Water Office (Bureau de l'Eau) in N'Djaména has a set of maps and the capacity to make copies for those interested (Hecht, 1993).

Determine spatial land use within a VT and observe changes over time, preferably by low level aerial video recordings. The best conditions for making an overflight are during the month of December. Two video sequences would be taken with one flight. One video series (recommend 1:10,000 scale) would record the entire VT area plus 25 percent fringe and "common lands." This would be used to define the boundaries of the VT and locate individual production areas, their size, and location relative to other land uses. The minimum recommended ground sample size (pixel) is 1.00 m. A second, more detailed video recording (recommend 1:1,000 scale) would be obtained by traversing more or less the center of the VT, called a transect because of narrow width (200 m) and the relatively long length (minimum 20 km) of the coverage. Hard copy photos can be generated from the

video to use for ground truthing. The purpose of the transect is to develop a key for identifying crops, fallows, trees, shrubs and grass stands, and other features on the less detailed video covering the entire VT. The transect also serves as a tool in long-range monitoring of vegetation changes. Farmers can use photos to plan village land use and to place their fields in relation to other resources within the VT.

Confirm physical features. By providing detailed ground truthing of video generated photos, with the aid of a global positioning system (GPS), the first year's work will facilitate subsequent monitoring activities. Ground truthing would include the confirmation of physical features, and scientific identification of plant species and plant associations. A suggested classification of land use/land cover would distinguish:

- roads, housing/village
- cultivated upland
- bare ground
- recession agriculture
- flood plain (non-agriculture)
- water (rivers, ponds, lakes)
- fallow (less than 5 years)
- shrub (species association)
- tree (species association)
- grass (species association)
- and canopy (closed forest canopy less than 15 m)

Establish baseline data. The geographic information system (GIS), coupled with low level aerial video reconnaissance, is an inexpensive effective means of recording and analyzing changing spatial features over time. An alternative system would be to take low level IR (infrared) photographs of VTs and do all the interpretation manually, with the aid of GPS and extensive ground truthing (see above for recommended scales). The increased time required to ground truth, make physical measurements, and complete manual interpretations would cost substantially more than aerial videos, and would give a much less viable finished product.

C2. Monitoring in Year Two and Thereafter

Monitoring in year two and thereafter means repeating the two low level video recordings for each VT, and allowing for limited ground truthing, photo interpretation, and computer time for entering and analyzing data (GIS). This will make it possible to identify changes in space occupied by individual species or species associations, as well as changes in land use.

Interviews are continued to determine both farmer inputs into land management practices and the underlying causes, such as intensification or extensification of cropping, use of fallows, agricultural chemicals, other soil fertility practices, village expansion, forest and tree management for fruit and firewood, changes in livestock and oxen numbers, and changes in water sources. With the combination of interviews and video reconnaissance techniques,

94

it shoule be possible to determine causes for changes in environmental habitats. This will require an in-depth review of all aspects of the environment.

D. Mitigation

Considering the present degrading trend of the environment, the complexity of actors, and multitude of conditions causing the degradation, money to support such a narrow monitoring effort might be better used in mitigation. This should occur through a series of steps:

- Use the monitoring data collection exercise to encourage villages to look at their own environments, identify their own deficiencies and problems, and set their own priorities. Encourage village units to find their own solutions to community problems. Minimal technical support for the village units would be necessary.

- Encourage youth education programs on sustaining production of forest and rangeland resources within their village area.

- Encourage the GOC to develop legislation defining uses of land, particularly caretaker user rights, and periods when nomadic/transhumant herds may move into intensive agricultural production areas. Legislation should spell out what rights each land user has regarding pasture, water, trees, and cultivation.

- Develop radio and other media campaigns to inform herders and animal owners when animals are allowed into certain areas of the country. Try to defuse the conflict between herders and crop farmers.

- Recommend that USAID/Chad explore an NRM program support system for PVO and NGO activities. Every village-level program should have a designed NRM component to decelerate degradation of the environment, which is flexible and based on identifiable village group needs.

APPENDIX B-1
BIBLIOGRAPHY

"A Conceptual Approach to the Conservation and Management of Natural Forests in Sub-Saharan Africa (Arid and Semi-Arid Forests and Woodlands)," concept paper, 115 pp., prepared for Natural Resources Management Support project (NRMS) by Associates in Rural Development, Inc. (ARD), USAID, March 1991.

Actualisation des Connaissances sur les Ressources en Eau Souterraine de la République du Tchad, technical paper, Parts I and II, Ministère de l'Elevage et de l'Hydraulique Pastorale, Office National de l'Hydraulique Pastorale et Villagois, December 1987.

"Assale/Serveouel Project Paper," UNDP, The Chad Basin Commission, Fort Lamy, Chad, 1970.

Berhaut, J., *Flore du Sénégal,* 2ème édition, Editions Clairafrique, Dakar, 1967.

Carter, M. G., and G. B. McLeroy, "Range Management and Livestock Industry, Chad Basin," technical report, USDA, for The Chad Basin Commission, Fort Lamy, Chad, August 1968.

Conservation des Ressources Naturelles et Développement Rural, technical report, parts II and III, Projet de Réhabilitation du Secteur Agricole, Ministère du Plan et de la Coopération, Tchad. Etude réalisée en sous-traitance par le Centre Technique Forestier Tropical, Louis Berger International, et BCEOM, January 1989.

Dalziel, J. M., and J. Hutchinson, Flora of West Tropical Africa, four volumes and six parts, Crown Agents for Overseas Governments and Administrations, Millbank, London, rev. 1972.

Etude des Perspectives de la Commercialisation du Bétail et des Produits de l'Elevage, technical paper, Volume I, Louis Berger International, Inc. and BCEOM, Ministère du Plan et de la Coopération, N'Djaména, May 1988.

"Etude du Milieu," Questionnaire, Projet de Développement Communautaire, Sarh, Tchad, 15 pp., CARE/CANADA/TCHAD, October 1992.

Etude d'Impact du Second Projet Sectoriel des Transports, Ministère des Travaux Publics et des Transports, Tchad, August 1990.

Etudes de Préparation du Second Projet Sectoriel des Transports, Technical Report, 33 pp. plus annexes, Volumes II and III, Ministère des Travaux Publics et des Transports, Tchad, October-November 1992.

Gaston, A., D. Dulieu, G. Lamarque, (IEMVT), et Ch. Bouquet, Ch. Clanet, Ch. Seignobos (Université du Tchad), Agropastoral Survey No. 53, CBLT, Tchad, République Française, Ministère de la Coopération, Paris, par l'Institut d'Elevage et de Médecine Vétérinaire des Pays Tropicaux, synthèse Agropastorale du Bassin du Lac Tchad, December 1979.

Gilruth, P., C. Hutchinson, and B. Barry, "Assessing Deforestation in the Guinea Highlands of West Africa Using Remote Sensing," Photogrammetric Engineering and Remote Sensing, Vol. 56, No. 10, pp. 1375-1382, October 1990.

Hamel, O., A. Gaston, A. Bertrand, et al., *Conservation des Ressources Naturelles et Développement Rural, rapport, 1ère partie: Ressources, Besoins, Diagnostique*, 157 pp., Ministère du Plan et de la Coopération, Projet de Réhabilitation du Secteur Agricole, Tchad, Conservation des Ressources Naturelles et Développement Rural, April 1988.

Hecht, J., "Rapport pour la Cellule Technique d'Appui à la Mise en Oeuvre du Plan Directeur de Lutte Contre la Désertification: Elaboration d'un Programme National du Connaissance et du Suivi des Ressources Naturelles," January 1993.

Hutchinson, C., R. Schowengerdt, and L. Baker, "A Two-Channel Multiplex Video Remote Sensing System," *Photogrammetric Engineering and Remote Sensing*, Vol. 56, No. 8, pp. 1125-1128, August 1990.

Innes, R. R., and W. D. Clayton, *Descriptions and Key: A Manual of Ghana Grasses.* Ministry of Overseas Development, Land Resource Division, Surbiton, Surrey, England, 1977.

Inventaire de Ressources Agro-Silvo-Pastorales du Borkou-Ennedi-Tibesti (B.E.T.), *République du Tchad*, drawn up by Agrotechnik for the Bureau des Nations Unies pour la Région Soudano-Sahelienne, BNUS/UNSO, August 1990.

Kindler, J., E. Warshall, C. Arnould, F. Hutchinson, and R. Varady, "A Diagnostic Study of Environmental Degradation, of the Lake Chad Conventional Basin," Technical Report, Institute of Environmental Engineering, Warsaw Technical University and Office of Arid Lands Studies, University of Arizona, for UNEP and UNSO, November 1989.

_____ and P. Warshall, Final Draft, "Master Plan for The Development of the Environmentally Sound Management of the Natural Resources of the Conventional Lake Chad Basin Area," September 1990.

"Les Couloirs de Transhumance et les Puits Pastoraux," internal study, Direction de l'Elevage et des Services Vétérinaires, N'Djamena, September 1989.

Marsh, S., J. Walsh, and C. Hutchinson, "Development of an Agricultural Land-Use GIS for

Senegal Derived from Multispectral Video and Photographic Data," *Photogrammetric Engineering and Remote Sensing*, Vol. 56, No. 3, pp. 351-357, March 1990.

_____, J. Walsh, C. Lee, and L. Graham, "Multitemporal Analysis of Hazardous Waste Sites through the Use of a New Bi-Spectral Video Remote Sensing System and Standard Color IR Photography," *Photogrammetric Engineering and Remote Sensing*, Vol. 57, No. 9, pp. 1221-1226, September 1991.

Maydell, H. J., *Trees and Shrubs of the Sahel, Their Characteristics and Uses*, 525 pp., GTZ, 1986.

Ozenda, P., *Flore du Sahara*, 2ème édition, 622 pp., Edition du Centre National de la Recherche Scientifique, Paris.

Pias, J., "La Végétation du Tchad," Travaux et Documents de l'ORSTOM No. 6, Paris, 1970.

Plan Directeur de Lutte Contre la Desertification: Diagnostique de la Situation, Plan d'Action, et Proposition de Programmes, Tchad, UNSO/CILSS, February 1989.

Roberty, G., *Petite Flore de l'Ouest-Africain*, 441 pp., Office de la Recherche Scientifique et Technique Outre-Mer, Paris, 1954.

Shar, H., R. Dagbo, and C. Paskett, "Review of the Agriculture Sector," prepared for USAID, Chad, by Experience, Inc., May 1992.

Statistique 1991, Ministère du Développement Rural, Division de la Statistique Agricole, N'Djamena, April 1992.

"Suivi des Marchés à Bétail," papier technique, Ministère de l'Elevage, N'Djamena, August 1992.

APPENDIX B-2
FIELD TRIP OBSERVATIONS

N'DJAMENA-DONGGIA-HADJER EL HAMIS-KARAL-MANI-DONGGIA

Prefecture:	Chari-Baguirmi, south of Lake Chad
References:	-Dalziel and Hutchinson, 1954-1972 -Roberty, G., 1954 -Pias, J., 1970 -Innes and Clayton, 1977 -I.E.M.V.T.-1979 -Hamel, O., 1988 *-Statistique, 1991*
Surface areas:	82,190 km^2 *(Statistique, 1991)*
Population density:	11 person per km^2 (reflects high urban population of N'Djamena)
Cultivated surface:	.8% (Hamel, 1988)
Parks and Reserves:	138,000 ha Wildlife Reserve (Hamel, 1988)
N'Djamena rainfall:	456 mm (average 1984-1991) *(Statistique, 1991)*
Days of rainfall:	46 (average 1984-1991), May-September
Livestock population: (1991 estimates)	Cattle 831,283 Sheep/goats 998,523 Camels 61,491 Donkeys 51,184 Horses 26,112 Pork 1,218 *(Statistique, 1991)*
Traction Oxen:	no info *(Statistique, 1991)*

TREES:	*Acacia albida*	
	A. seyal	
	Balanites aegytiaca	
	Acacia nilotica	three varieties reported
	Ziziphus mauritiana	
	Calotropis procera	abundant around villages
	Tamarindus indica	Tamarind, by villages
	Mitragna inermis	
	Borassus aethiopum	Rhum Palm, endangered
	Piliostigma reticulatum	large leaf
	Hyphaene thebaica	Doum Palm, endangered
	Sclerocarya birrea	
	Azadirachta indica	Neem (planted)
SHRUBS:	*Salvadora persica*	Tooth cleaning wood is abundant around Hadjer el Hamis; green and 2 m high.
FORBS:	*Blepharis linaraefolia*	30 cm high, and dry
GRASSES:	*Andropogon gayanus*	(endangered), Hadjer el Hamis
	Eragrostis tremula	
	Pennesetum pedicilatum	
	Schoenefeldia gracilis	
	Setaria pallide-fusca	
	Panicum laetum	stored residue
	P. subalbidum	stored residue
	Echinochloa colona	
	Chloris pilosa	
	Dactyloctenium aegyptiacum	stored residue
	Setaria palide-fusca	

N'DJAMENA-GUELENDENG

Prefecture: Chari Baguirmi, south of N'Djaména

References:
-Dalziel and Hutchinson, 1954-1972
-Roberty, G., 1954
-Pias, J., 1970
-Innes and Clayton, 1977
-I.E.M.V.T.-1979
-Hamel, O., 1988
-*Statistique, 1991*

Surface areas: 82,190 km^2

Population density:	11 persons/km² (reflects urban population of N'Djaména)
Cultivated surface:	0.8% (ONDR 1987)
Parks and Reserves:	138,000 ha Wildlife Reserve
Guelendeng rainfall:	616 mm (average 1984-1991)
Days of rainfall:	59 (average 1984-1991), May-October

Livestock population: (1991 estimates)		
	Cattle	831,283
	Sheep/goats	998,523
	Camels	61,491
	Donkeys	51,184
	Horses	26,112
	Pork	1,218

Traction Oxen:	no info	
TREES:	*Acacia seyal*	
	A. nilotica	
	A. sieberiana	
	A. albida	
	Balanites aegyptiaca	
	Hyphaene thebaica	rare
	Ziziphus mauritiana	
	Ficus sp.	
	Terminalia macroptera	
	Combretum sp.	
	Anogeissus leiocarpus	
	Sclerocarya birrea	
	Khaya senegalensis	
	Prosopis africana	
	Borassus aethiopum	(endangered), rhum palm
	Eucalyptus sp.	plantations
	Azadirachta indica	Neem, plantation
SHRUB:	*Piliostigma reticulatum*	
GRASSES:	*Eragrostis tremula*	
	Pennisetum pedicellatum	
	Schoenefeldia gracilis	
	Dactyloctenium aegyptiacum	
	Setaria pallide-fusca	
	Panicum laetum	stored crop residue
	P. subalbidum	stored crop residue

Echinochloa colona
Chloris pilosa

RESIDUES: Pénicillaire, *Pennisetum americanum* (millet) stalks are bundled and stored. Panicum spp., et al. are bundled and stored for livestock feed. Bundles of roof thatching *(Andropogon gayanus, Hyparrhenia rufa,* and other *H. spp.)* are also stored.

OTHER: There were no firewood or charcoal bundles along road; burned bushland, clearing of trees for cultivation; vegetation/soil degradation accelerating; nomadic cattle herds; N'Bororo, Arab; and nomadic camps located west of highway.

MBERE - MOSGOUGOU - BOUSSO - MILTOU

Prefectures: Southern part of Chari-Baguirmi, north eastern portion of Mayo Kebbi

References:
-Dalziel and Hutchinson, 1954-1972
-Roberty, G., 1954
-Pias, J., 1970
-Innes and Clayton, 1977
-I.E.M.V.T.-1979
-Hamel, O., 1988
-*Statistique, 1991*

Surface areas: 30,105 km^2 (Mayo Kebbi)

Population density: 15 person per km^2 (Mayo Kebbi)

Cultivated surface: no info

Parks and Reserves: 64,000 ha of Classified Forest and 135,000 ha of Animal Reserves

Rainfall in Bousso: 752 mm (average 1984-1989, 1991)

Days of rainfall: 56 (average 1984-1989, 1991), May-October

Livestock population: (Mayo-Kebbi- 1991 estimates)

Cattle	106,906
Sheep/goats	506,894
Camels	no info
Donkeys	12,016
Horses	1,877
Pork	6,395

Traction Oxen:	38,960 (1987), +39% net 5 year gain	
TREES:	*Piliostigma reticulatum*	
	Balanites aegyptiaca	
	Anogeissus leiocarpus	
	Hyphaene thebaica	(endangered), doum palm
	Combretum glutinosum	
	C. sp.	
	Terminalia sp.	
	Ficus sp.	
	Acacia seyal	
	A. nilotica	
	A. sieberiana	
	A. albida	
	Diospyros mespliformus	
	Burkea africana	
	Tamarindus indica	
	Khaya senegalensis	
	Parkia biglabosa *néré*	
SHRUB:	*Ziziphus mucronata*	
	Z. spina-christi	
	and/or	
	Z. mauritiana	
FORBS:	*Cochlospermum tinctorium*	
GRASSES:	*Eragrostis tremula*	
	Pennisetum pedicellatum	
	Schoenefeldia gracilis	
	Setaria pallide-fusca	
	Panicum laetum	stored crop residue
	P. subalbidum	stored crop residue
	Echinochloa colona	
	Chloris pilosa	
	Hyparrhenia rufa	
	Hyparrhenia sp.	
	Andropogan gayanus	
	Dactyloctenium aegyptiacum	
RESIDUES:	Thatching is being stored in villages.	
OTHER:	There was sacked charcoal along roadway near Miltou awaiting buyer from Sarh; slash and burned areas predominate; open fallow with remanent forest; open canopy under 5 m; large standing dead trees near Miltou probably attributed to drought	

and repeated wildfires; wildfires are very common; and manioc *(Manihot esculentia)* grown

MILTOU - KOUNO - GAYAM - N'GERE - SARH

Prefectures:	Northwest portion of Moyen-Chari and northeast portion of Mayo-Kebbi
References:	-Dalziel and Hutchinson, 1954-1972 -Roberty, G., 1954 -Pias, J., 1970 -Innes and Clayton, 1977 -I.E.M.V.T.-1979 -Hamel, O., 1988 -*Statistique, 1991*
Surface area:	45,180 km^2 (Moyen-Chari)
Population density:	15 persons per km^2
Cultivated surface:	5% (fallow not included)
Parks and Reserves:	414,254 ha of Classified Forests, and 114,000 ha in National Parks
Rainfall in Sarh:	831 mm (average 1984-1990)
Days of rainfall:	75 (average 1984-1989), April-October

Livestock population: (Moyen-Chari-1991 estimates)		
	Cattle	474,952
	Sheep/goats	173,916
	Camels	no info
	Donkeys	no info
	Horses	4,060
	Pork	2,814

Traction Oxen:	42,220 (1987), +26% net 5 year gain
TREES:	*Isoberlinia doka* *Terminalia laxifolia* *T. avicennoides* *Anogeissus leiocarpus* *Pterocarpus lucens* *Prosopis africana* *Parkia biglabosa* *Burkea africana*

106

	Daniellia oliveri	
	Khaya senegalensis	
	Butyrospermum paradoxum	karité, shea butter
	Hyphaene thebaica	endangered, doum palm
	Ficus sp.	
	Mangifera indica	mango (planted)
	Borassus aethiopum	endangered, rhum palm
SHRUBS:	*Entada africana*	
	Combretum collinum	
	C. nigricans	
	Securidaca longepedunculata	
	Piliostigma reticulatum	
	Oxynanthera abyssinica	bamboo
	Strychnos spinosa	
	Gardenia erubescens	
FORBS:	*Cochlospermum tinctorium*	
GRASSES:	*Andropogan gayanus*	
	Hyparrhenia spp.	
	H. rufa	
	Ctenium sp.	
	Diheteropogon amplectens	
	Eragrostis sp.	
	Dactyloctenium aegyptiacum	
	Chloris pilosa	
	Panicum spp.	

OTHERS:

Tree savannah is degraded by cultivation.

Rare bamboo *(Oxynanthera abyssinica)* stands occur south of Kouno.

Cut firewood was bundled along highway after Kouno, probably destined for Sarh.

There was a stretch of red soil around Kouno.

It was very common to see slashing and burning in fields along the highway.

The secondary growth is under 5 m high with an occasional tree to 10 m plus.

SARH - KOUMRA - DOBA - MOUNDOU

Prefectures:	Moyen-Chari and Logone Oriental
References:	-Dalziel and Hutchinson, 1954-1972 -Roberty, G., 1954 -Pias, J., 1970 -Innes and Clayton, 1977 -I.E.M.V.T.-1979 -Hamel, O., 1988 -*Statistique, 1991*
Surface areas:	28,035 km^2 (Logone Oriental)
Population density:	15 persons per km^2
Cultivated surface:	7% (ONDR 1986)
Parks and Reserves:	430,940 ha of Classified Forests
Rainfall in Doba:	961 mm (average 1985-1990)
Days of rainfall:	65 (average 1985-1989), April-October
Livestock population: (Logone Oriental-1991 estimates)	Cattle 72,243 Sheep/goats 161,524 Camels no info Donkeys no info Horses 6,242 Pork 1,218
Traction Oxen:	21,600 (1987), +20% net 5 year gain
TREES:	*Daniellia oliveri* *Burkea africana* *Terminalia laxoflora* *Pterocarpus lucens* *T. macroptera* ***Borassus aethiopum* rhum palm ***Parkia biglobosa* néré *Khaya senegalensis* *Prosopis africana* *Anogeissus leiocarpus* ***Mangifera indica* mango *Diospyros mespiliformis* ***Acacia albida*

108

	***Butyrospermum paradoxum*	karité or shea butter
	Isoberlinia doka	
	Hyphaene thebaica	doum palm
SHRUB:	*Mimosa pigra*	common along river banks
	Ziziphus spp.	
	Lannea sp.	
	Gardenia sp.	
	Asparagus sp.	
	Piliostigma reticulatum	
FORBS:	*Cochlospermum tinctorium*	
GRASSES:	*Vetivaria nigritana*	
	Panicum turgidum	
	Andropogon gayanus	
	A. schirensis	
	Schoenfeldia gracilis	
	Panicum anabaptistum	
	Panicum sp.	
	Hyparrhenia rufa	
	H. spp.	
	Paspalum orbiculare	
	Echinochloa stagnina	
	Chloris robusta	
	C. pilosa	
	Eragrostis spp. (2)	
	Schizachyrium sanquineum	
	Beckeropsis uniseta	
	Dactyloctenium aegyptiacum	
	Setaria palide-fusca	
RESIDUES:	*Arachis hypogea*	groundnut hay
	Pennisetum americanum	Pénicillaire or millet stalks are bundled and stored platforms in village.

**Predominate woody species in cultivated areas between Bedaya-Koumra-Doba.

OTHERS: Early in day two cattle herds of Fulani white and one N'Bororo herd were observed. Fallows were 2-4 years old. Burning is common in the fallow/open savannah.

Secondary growth is under 5 m high with occasional tree to 10 m plus. Large cultivated areas between Bedaya-Koumra-Doba with **5 tree species in open stands.

30+ nomadic dwellings were installed on the south shore of the Logone River near the approach to the bridge at Moundou (March 1993).

MOUNDOU - MBATA - BENOY - DOHER

Prefecture:	Logone Occidental
References:	-Dalziel and Hutchinson, 1954-1972 -Roberty, G., 1954 -Pias, J., 1970 -Innes and Clayton, 1977 -I.E.M.V.T.-1979 -Hamel, O., 1988 -*Statistique, 1991*
Surface Area:	7,695 km^2
Population density:	38 persons per km^2
Cultivated surface:	18.7%, no fallow (ONDR 1986)
Parks and Reserves:	583,990 ha of Classified Forests
Rainfall in Moundou:	817 mm (average 1984-1990)
Days of rainfall:	78 (average 1984-1990), April-October

Livestock population: (1991 estimates)

Cattle	71,465
Sheep/goats	136,639
Camels	no info
Donkeys	no info
Horses	5,151
Pork	1,439

Traction Oxen: 15,770 (1987), +26% net 5 year gain

TREES:

Hyphaene thebaica	endangered, dune palm
Mangifera indica	mango (planted)
Bombax costatum	trees in family groups
Anacardium occidentale	cashew (planted)

SHRUBS:	*Terminalia laxiflora*	normally a tree
	T. macroptera	
	Burkea africana	normally a tree
	Prosopis africana	normally a tree
	Gardenia sp.	
	Combretum nigricans	
	Calotropis procera	
	Acacia sp.	
GRASSES:	*Ctenium newtonii*	
	Andropogon gayanus	
	Hyparrhenia spp.	
	Eragrostis sp.	
	Pennisetum pedicellatum	
	Hyperthelia dissoluta	
	Imperata cylindrica	
	Chloris pilosa	
	Dactyloctenium aegyptiacum	

OTHER: The ecosystem is overused and abused. High population density. No extra land, no fallow lands. The tree savannah is cleared for agriculture. Vegetation is not very rich in species. Women are walking up to 15 km for firewood.

Village of Doher committee has planted 677 trees in woodlot of 1.8 ha, they seem aware of lack of firewood supply,particularly for future generation. Doher has abandoned fields because of poor productivity. The two different village committees interviewed each had hostile problems with nomadic/ transhumant herders, whose animals have eaten maturing crops in the rainy season (Farmers' viewpoint).

MOUNDOU - KELO - PALA

Prefectures: Logone Occidental, Tandjilé, and Mayo Kebbi

References:
-Dalziel and Hutchinson, 1954-1972
-Roberty, G., 1954
-Pias, J., 1970
-Innes and Clayton, 1977
-I.E.M.V.T.-1979
-Hamel, O., 1988
-*Statistique, 1991*

Surface areas: 18,045 km^2 (Tandjilé)

Population density:	22 persons per km^2 (Tandjilé)
Cultivated surface:	19% (without fallow)
Parks and Reserves:	0%
Rainfall in Kélo:	826 mm (average 1985, 1988-1990)
Days of rainfall:	58 (average 1985, 1988-1989, 1991), April-October

Livestock population: (Tandjile 1991 -estimates)		
	Cattle	53,586
	Sheep/goats	127,710
	Camels	no info
	Donkeys	no info
	Horses	10,521
	Pork	1,439

Traction Oxen:	28,930 (1987), +28% net 5 year gain

TREES:	*Albizia chevalieri*	
	Balanites aegyptiaca	
	Burkea africana	
	Pterocarpus lucens	
	Terminalia macroptera	
	T. laxifolia	
	Vitex doniana	
	Prosopis africana	
	Anogeissus leiocarpus	
	Piliostigma reticulatum	
	Parkia biglobosa	
	Tamarindus indica	
	Khaya senegalensis	
	Bombax costatum	
	Entada africana	
	Mangifera indica	mango (planted)
	Butyospermum parkii	karité or shea butte.
	Sclerocarya birrea	
SHRUB:	*Acacia macrostachya*	
	Combretum glutinosum	
	Pseudocedrela kotschyi	
	Strychnos spp.	
	Gardenia ternifolia	
FORBS:	*Asparagus africanus*	

GRASSES:	*Andropogon sp.*	reddish, 1 m, poor thin soils, upland sites
	A. gayanus	
	Loudetia annua	
	Hyparrhenia rufa	
	H. bagirmica	
	H. dissoluta	
	Sporobolus festivus	
	Cyperaceae	sedges and carex
	Diheteropogon sp.	
	Eragrostis tremula	
	Ctenium sp.	
	Pennisetum pedicellatum	
	Chloris pilosa	
	Dactyloctenium aegyptiacum	

OTHER: Many fallows of 1-2 years were observed. Burned areas are frequent. Rolling intermittent lateritic uplands predominated by annual grasses and shrubs between Kélo and Pala.

PALA - LERE

Prefecture: Mayo Kebbi - southwestern part

References:
-Dalziel and Hutchinson, 1954-1972
-Roberty, G., 1954
-Pias, J., 1970
-Innes and Clayton, 1977
-I.E.M.V.T.-1979
-Hamel, O., 1988
-Statistique, 1991

Surface area: 30,100 km^2

Population density: 31 persons per km^2

Cultivated surface: 10.3% (ONDR, 1986)

Parks and Reserves: 6.6%

Rainfall in Pala: 951 mm (average 1985-1991)

Days of Rainfall: 70 (average 1985-1991), May-September

Rainfall in Lere: 735 mm (average 1985-1991)

Days of rainfall:	59 (average 1985-1991, only 7 years recorded)	
Livestock population: (Mayo-Kebbi 1991-1991 estimates)	Cattle	106,906
	Sheep/goats	506,894
	Camels	no info
	Donkeys	12,016
	Horses	1,877
	Pork	6,395
Traction Oxen:	38,960 (1987), +39% net 5 year gain	
TREES:	*Daniella oliveri*	
	Terminalia macroptera	
	T. avicennioides	
	Monotes kerstingii	
	T. laxifolia	
	Cassia sieberiana	
	Parkia biglabosa	
	Entada africana	
	Bombax constatum	
	Anogeissus leiocarpus	
	Butyrospermum paradoxum	karité or shea butter/poor
	Prosopis africana	
	Ficus platyphylla	
	Balanites aegyptiaca	
	Hyphaene thebaica	endangered, doum palm
	Borassus aethiopum	endangered, rhum palm
	Sterculia setigera	
	Sclerocarya birrea	
	Boswellia spp.	
	Mangifera indica	mango (planted)
	Albizia chevalieri	
	Acacia albida	
SHRUBS:	*Terminalia laxifolia*	
	Piliostigma reticulatum	
	Pseudocedrela kotschyi	
	Combretum glutinosum	
	C. nigricans	
	Gardenia spp.	
	Ziziphus mucronota	
	Z. mauritiana	
	and/or	
	Z. spina-christi	
	Acacia macrostachya	
	Mimosa pigra	

Sesbania sesban

GRASSES:

Andropogon gayanus
A. schirensis
Chloris pilosa
Cynodon dactylon
Diheteropogon ampletens
Dactyloctenium aegyptiacum
Hyparrhenia rufa
H. bagirmica
H. dissoluta
Diectomis fastifiata
Ctenium newtonii
Loudetia annua
L. togoensis
Pennisetum pedicellatum
Eragrostis tremula
E. atrovirens in marigots
Aristida sp.
Cyperaceae sedges and carex
Vetivaria nigritana
Setaria palide-fusca
Panicum sublaetum
P. anabaptistum
Paspalum orbiculare
P. sp.
Chloris robusta

RESIDUES:

Bérbéré stalks grown in the lower Mayo Kebbi are sold to livestockmen.

OTHERS:

A low growing tree/brush savannah occur on eroded upland lateritic and light brown clay loam soils.

Evidence of extended burning throughout the region.

Large areas of Bérbéré, corn, red sorghum, and vegetables such as niébé *(Vigna sp.)* and gombo *(Hibiscus esculentus)* are grown on shoreline of Lake Léré and up the Mayo Kebbi.

Large number cattle herds, Fulani, N'Bororo, and a mix of the two breeds, feeding around Lake Léré and up the Mayo Kebbi marsh, and watering in Lake Léré and at points along the Mayo Kebbi, which is still flowing (Fulani and Moundang herds). Herds are also coming from Cameroon.

PALA - SORGA - DJODA GASSA - TAGAL I - GOUNOU GAYA - vers KELO - ERE - DJOUMAN - G. TOUGOUDE

Prefecture:	Mayo-Kebbi
References:	-Dalziel and Hutchinson, 1954-1972 -Roberty, G., 1954 -Pias, J., 1970 -Innes and Clayton, 1977 -I.E.M.V.T.-1979 -Hamel, O., 1988 -*Statistique, 1991*
Surface area:	30,100 km^2
Population density:	31 persons per km^2
Cultivated surface:	10.3% (ONDR, 1986)
Parks and Reserves:	6.6%
Rainfall in Pala:	951 mm (average 1985-1991)
Days of rainfall:	70 (average 1985-1991), May-September

Livestock population: (Mayo-Kebbi 1991-estimates)

Cattle	106,906
Sheep/goats	506,894
Camels	no info
Donkeys	12,016
Horses	1,877
Pork	6,395

Traction Oxen: 38,960 (1987), +39% net 5 year gain

TREES:

Parkia biglabosa	
Butyrospermum paradoxum	karite or shea butter/poor
Anogeissus leiocarpus	
Prosopis africana	
Ficus spp.	
Balanites aegyptiaca	
Hyphaene thebaica	endangered, doum palm
Borassus aethiopum	endangered, rhum palm
Sterculia setigera	
Khaya senegalensis	
Acacia nilotica	
A. siebriana	

	Entada africana	
	Terminalia avicinnioides	
	Cassia sieberiana	
	Tamarindus indica	
	Diospyros mespiliformis	
	Mangifera indica	mango (planted)
SHRUBS:	*Terminalia laxifolia*	
	Combretum glutinosum	
	C. hypopilinum	
	Guiera senegalensis	
	Piliostigma thonningii	
	P. reticulatum	
	Gardenia spp.	
	Ziziphus mauritiana	
	and/or	
	Z. spina-christi	
	Z. mucronata	
	Strychnos spinosa	
FORBS:	***Hydrolea floribunda*	
	***Ammania auriculata*	
GRASSES:	*Andropogon gayanus*	
	A. pseudapricus	
	***Hyparrhenia rufa*	
	Hyperthelia dissoluta	
	Diheteropogon amplectens	
	Diectomis fastifiata	
	***Vetivaria nigritana*	
	Pennisetum pedicellatum	
	***Elytrophorus spicatus*	
	Loudetia sp.	
	Panicum laetum	
	P. spp.	
	Chloris pilosa	
	Paspalum sp.	
	Dactyloctenium aegyptiacum	
	Echinochloa colona	

**Species occur in flood plains

Four or five village cattle were observed around each village.

117

250-60 unit White Arab herds were observed grazing in the flood plain south-east of Gounou Gaya. Three village draft oxen were being watered from a well in Tagal I.

TOUGOUDE - BONGOR - GUELENDENG

Prefecture: Mayo Kebbi - eastern portion

References:
-Dalziel and Hutchinson, 1954-1972
-Roberty, G., 1954
-Pias, J., 1970
-Innes and Clayton, 1977
-I.E.M.V.T.-1979
-Hamel, O., 1988
-*Statistique, 1991*

Surface Area: 30,100 km^2

Population density: 31 persons per km^2

Cultivated surface: 10.3% (ONDR, 1986), without fallow

Parks and Reserves: 6.6%

Rainfall in Bongor: 730 mm (average 1984-1991)

Days of rainfall: 62 (average 1984-1991), June-September

Livestock population: (Mayo-Kebbi 1991 -1991 estimates)

Cattle	106,906
Sheep/goats	506,894
Camels	no info
Donkeys	12,016
Horses	1,877
Pork	6,395

Traction Oxen: 38,960 (1987), +39% net 5 year gain

TREES:
Prosopis africana
Combretum glutinosum
Anogeissus leiocarpus
Khaya senegalensis
Hyphaene thebaica — doum palm (used to weave mats)—leafy seedlings
Sclerocarya birrea

118

	Borassus aethiopum	very few Roniers, lone individuals occur near inundated land, near waterways, (endangered)
	Terminalia macroptera	
	T. avicennioides	
	Acacia albida	
	A. sieberiana	
	A. nilotica	
	A. seyal	
	Ficus platiphylla	
	Balanites aegytiaca	
	Piliostigma reticulatum	
	Parkia biglobosa	nerié (poor growth)
	Tamarindus indica	
	Azadirachta indica	neem (planted)
	Mangifera indica	mango (planted)
SHRUBS:	*Ziziphus mauritiana* and/or *Z. spina-christi*	
	Guiera senegalensis	
	Mitragna inermis	
	Mimosa pigra	
	Calotropis procera	
FORBS:	*Euphorbia sp.*	
	Leptadenia sp.	abundant north of Bongor
	***Hydrolea floribunda*	
	***Ammania auriculata*	
GRASSES:	***Hyparrhenia rufa*	
	Hyperthelia dissoluta	

** Species occuring in flood plain

Diheteropogon amplectens	
***Elytrophorus spicatus*	
Andropogon gayanus	
A. pseudapricus	
***Vetivaria nigritana*	
Pennisetum pedicellatum	
Eragrostis tremula	
Schoenefeldia gracilis	
Panicum laetum	collected/stored crop residue
P. subalbidum	collected/stored crop residue

Echinochloa colona
Chloris pilosa
Dactyloctenium aegyptiacum

RESIDUES: Sorghum and millet stalks being stored on platforms in almost every village.

Thatching materials *(Hyparrhenia rufa,* other *H. spp.*, and *Andropogon gayanus)* are gathered and abundantly stored in every compound, and every village along roadway.

Weaving materials (Dune Palm), non-woody growth is abundant in spots along road.

OTHERS: Farmers are strip cropping Taro *(Colocasia antiquorum)* in flood plains of Logone River (or cocoa yam). Deep plowing strips with heavy machinery is destroying natural stands of *Hyparrhenia rufa* and other bunch grasses, and replaced with secondary species of *Panicum spp.* furnishing feed for big flocks of Quelea *quelea* birds. (observed mid-March 1993)

Villages are frequent along the main roadway, fronting the Logone River.

Commercial firewood bundles started appearing along the roadway shortly after leaving the Bongor area.

Cattle herds were observed all along the way.

Burned landscape started after leaving the influence of Bongor.

Calotropis procera started showing up after the large town of Mounkou.

** Species occuring in flood plain

Bags of charcoal and bundles of firewood were abundant along roadway northeast of Mounkou.

Tree height was under 5 m approaching Guelendeng.

Guiera senegalensis was in abundance after departing Bongor.

Leptadenia lancifolia was in abundance after departing Bongor.

120

ABECHE - 25 KM SOUTH

Prefecture:	Ouaddaï
References:	-Dalziel and Hutchinson, 1954-1972 -Roberty, G., 1954 -Pias, J., 1970 -Innes and Clayton, 1977 -Ozenda, P., 1983 -Maydell, H. J., 1986 -Hamel, O., 1988 -*Statistique, 1991*
Surface areas:	77,240 km^2
Population density:	6 persons per km^2
Cultivated surface:	.9% (appears to be a very low %)
Parks and Reserves:	0%
Abeche rainfall:	327 mm (average 1986-1991)
Days of rainfall:	39 (average 1986-1991), July-September
Range of rainfall:	250 mm in north, 550 mm in south
Livestock population: (1991 estimates)	Cattle 426,721 Sheep/goats 267,666 Camels 122,848 Donkeys 54,417 Horses 20,553 Pork no info
Traction oxen:	no info
TREES:	*Acacia nilotica* *A. sp.* *A. albida* *A. seyal* *Commiphora africana* *Celtis integrigolia* *Balanites aegyptiaca* *Piliostigma rufescens* very small bi-partate leaf *Anogeissus leiocarpus* *Hyphaene thebaica* (endangered), doum palm

121

	Maerua crassifolia	
	Parkinsonia aculeata	Extensively planted in villages and front of dam/dikes (AFRICARE).
	Prosopis juliflora	planted (AFRICARE)
SHRUBS:	*Calotropis procera*	
	Boscia senegalensis	
	Combretum glutinosu	
	Ziziphus mauritiana	
	Capparis decidua	
FORBS:	*Crotalaria sp.*	
	Tephrosia sp.	
	Datura sp.	
	Indigofera sp.	It occurs in thick stands in wadis, or behind dikes.
	Ricinus communis	Castor bean, the contains an oil used in pharmaceutical. Camels were observed eating leaves. Appears to have been planted along seasonal waterways.
	Cassia sp.	30 cm high, in open fields
GRASSES:	*Cenchrus biflorus*	cram cram
	Hyparrhenia rufa	
	Schoenefeldia gracilis	
	Eragrostis tremula	
	Aristida spp.	
	Ctenium elegans	
	Dactyloctenium aegyptiacum	
RESIDUES:	Millet stalks are being cut and carried, stored on wooden platforms in village compounds.	
OTHERS:	Sandy soils were bare of ground cover.	
	Shrubs are well eaten by roving cattle and camels.	
	The wadis had more tree and shrub growth and uneaten forbs.	
	There was not much in grass and forbs to identify, the ground was clean, just sand, and stone outcroppings where there were mountains.	

ABECHE - AM DOUT GOZ - AM HIMEDE' - OUM HADJER

Prefecture:	Ouaddaï and Batha
References:	-Dalziel and Hutchinson, 1954-1972 -Roberty, G., 1954 -Pias, J., 1970 -Innes and Clayton, 1977 -Ozenda, P., 1983 -Maydell, H. J., 1986 -Hamel, O., 1988 -*Statistique, 1991*
Surface areas:	88,800 km^2 (Batha)
Population density:	5 persons per km^2
Cultivated surface:	.7%
Parks and Reserves:	0%
Ati rainfall:	349 mm (average 1986-1990)
Days of rainfall:	37 (average 1987-1990)
Range of rainfall:	no info
Livestock population: (1991 estimates)	Cattle 712,602 Sheep/goats 993,435 Camels 81,164 Donkeys 34,649 Horses 26,214 Pork no info
Traction oxen:	no info
TREES:	*Acacia nilotica* *A. scorpiodes* *A. albida* *A. laeta* *A. mellifera* *A. seyal* *A. senegal* *A. sieberiana* *Albizia sericocephala* *Commiphora africana*

127

	Celtis integrigolia	
	Balanites aegyptiaca	
	Piliostigma rufescens	Leaves are under 2 cm long.
	Anogeissus leiocarpus	Many dead trees 100 km west of Abéché, west of Am Himedé. Caused by drought.
	Hyphaene thebaica	(endangered), doum palm
	Dalbergia melanoxylon	
	Dicrostachys glomerata	
	Maerua crassifolia	
	Tamarindus indica	
SHRUBS:	*Guiera senegalensis*	
	Calotropis procera	
	Boscia senegalensis	
	Combretum glutinosu	
	Ziziphus mauritiana	
	Capparis decidua	
FORBS:	*Colocynthis sp.*	desert melon
	Cucumis sp.	hanging melon
GRASSES:	*Cenchrus biflorus*	cram cram
	Schoenefeldia gracilis	
	Eragrostis tremula	
	Aristida mutabilis	
	A. adscensionis	
	Ctenium elegans	
	Dactyloctenium aegyptiacum	
	Loudetia togoensis	
RESIDUES:	Millet stalks are stored in fields on platforms and in trees.	
OTHERS:	Bare ground was everywhere. Tree species are more concentrated along drainageways.	
	One jackal with a dead rabbit in his mouth was observed 40 km west of Abéché.	
	This region is important dry season rangeland. Nineteen nomad camps, 30 cattle herds, 16 flocks of small ruminants (including 9 flocks of blacksheep) were observed in the 100 km between Abéché and west of Am Himedé.	

124

OUM HADJER - SARAF DOUNGOUS

Prefecture: Batha and Guéra

References:
-Dalziel and Hutchinson, 1954-1972
-Roberty, G., 1954
-Pias, J., 1970
-Innes and Clayton, 1977
-Ozenda, P., 1983
-Maydell, H. J., 1986
-Hamel, O., 1988
-*Statistique, 1991*

Surface areas: 58,950 km^2 (Guéra)

Population density: 4.6 persons per km^2

Cultivated surface: 2.5%

Parks and Reserves: 536,000 ha of Wildlife Reserve

Mongo rainfall: 564 mm (average 1984-1990)

Days of rainfall: 52 (average 1984-1990), May-September

Range of rainfall: 450 mm in north to 800 mm in south

Livestock population:
(1991 estimates)

Cattle	558,213
Sheep/goats	186,276
Camels	61,491
Donkeys	28,458
Horses	18,156
Pork	no info

Traction oxen: no info

TREES:
Acacia sp.
A. seyal
Anogeissus leiocarpus
Balanites aegyptiaca
Commiphora africana
Hyphaene thebaica (endangered), doum palm
Tamarindus indica
Capparis decidua
Dichrostachys glomerata

SHRUBS:	*Piliostigma rufescens*	Leaves are under 2cm. long.
	Boscia senegalensis	solid stand for several km south of Oum Hadjer
	Calotropis procera	
	Maerua crassifolia	
	Ziziphus mauritiana	
	Capparis decidua	
FORBS:	*Colocynthis sp.*	desert melon
	Cucumis sp.	hanging melon
GRASSES:	*Andropogon sp.*	
	Aristida spp.	
	Brachiaria deflexia	
	B. distichophylla	
	Cenchrus biflora	
	Chloris pilosa	
	Ctenium elegans	
	Dactyloctenium aegypticum	
	Eragrostis tremula	
	Panicum turgidum	
	Schoenefleldia gracilis	

RESIDUES: Very few millet stalks were being stored.

OTHERS: Four nomadic camps, 14 cattle herds, and four flock of small ruminants were observed in this traditional dry season range area.

Vegetation type changed 90 km south of Oum Hadjer.

SARAF DOUNGOUS - MANGALME - MONGO - TOUBA ABDOUGAL - BITKINE

Prefecture: Guéra

References:
-Dalziel and Hutchinson, 1954-1972
-Roberty, G., 1954
-Pias, J., 1970
-Innes and Clayton, 1977
-Ozenda, P., 1983
-Maydell, H. J., 1986
-Hamel, O., 1988
-*Statistique, 1991*

TREES: *Acacia albida*

	A. nilotica	
	A. senegal	
	A. seyal	
	Albizia sericocephala	
	Anogeissus leiocarpus	
	Balanites aegyptiaca	
	Piliostigma reticulatum	
	P. rufescens	
	Boswellia papyrifera	
	Capparis decidua	
	Commiphora africana	
	Combretum glutinosum	
	Ficus sp.	
	Hyphaene thebaica	(endangered), doum palm
	Mangifera indica	mango (planted)
	Sclerocarya birrea	
	Sterculia setigera	
	Tamarindus indica	
	Terminalia avicennioides	
	T. brownei	
	Dalbergia melanoxylon	
	Azadirachta indica	neem (planted)
SHRUBS:	*Guiera senegalensis*	
	Gardenia ternifolia	
	Maerua crassifolia	
	Ziziphus mauritiana	
	Capparis decidua	
GRASSES:	*Androgogon pseudapricus*	
	Aristida funiculata	
	A. sp.	
	Brachiaria sp.	
	Cenchrus biflora	
	Chloris pilosa	
	Ctenium elegans	
	Dactyloctenium aegypticum	
	Eragrostis tremula	
	Loudetia sp.	
	Panicum sp.	
	Schoenefel dia gracilis	
OTHERS:	23 villages and 5 nomadic camps were located between Saraf Doungous and Mongo (140 km). 51 cattle herds were counted within the same area. 22 herds were over 40 head, the remaining 29 were under 40 head.	

BITKINE - BOKORO - ARBOUTCHATAK

Prefecture:	Guéra	
References:	-Dalziel and Hutchinson, 1954-1972 -Roberty, G., 1954 -Pias, J., 1970 -Innes and Clayton, 1977 -Ozenda, P., 1983 -Maydell, H. J., 1986 -Hamel, O., 1988 -*Statistique, 1991*	
TREES:	*Acacia albida*	occurs in cultivated fields
	A. ataxacantha	
	A. nilotica	
	A. seyal	
	Albizia chevalieri	
	Anogeissus leiocarpus	
	Azadirachta indica	neem (planted)
	Balanites aegyptiaca	
	Commiphora africana	
	Dalbergia melanoxylon	
	Dichrostachys glomerata	
	Hyphaene thebaica	(endangered), doum palm
	Maerua crassifolis	
	Tamarindus indica	
	Mangifera indica	mango (planted)
	Sclerocarya birrea	
	Piliostigma rufescens	
SHRUBS:	*Calotropis procera*	
	Guiera senegalensis	
	Ziziphus mauritiana	
	Boscia senegalensis	
	Capparis decidua	
GRASSES:	*Aristida funiculata*	
	Eragrostis tremula	
	Schoenefeldia gracilis	
	Ctenium elegans	
RESIDUES:	Millet stalks are collected and stored on platforms.	
OTHERS:	Thatching materials *(Hyperrhenia rufa)* were bundled and stored in almost every village along the road.	

ANNEX C

FOREST RESOURCES

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ANNEX C
FOREST RESOURCES IN CHAD

Almost all of the forests in Chad are woodlands or woodland savannahs, except an estimated 500 ha of closed forest along streams in the south. In this report, forests, woodlands, and woodland savannah will be referred to as forest. The amount and state of the forest resource and the present location of vegetation zones is not known. There has never been a forest inventory in Chad. Forest vegetation zones moved south during the drought and tree species have not stabilized enough to determine the extent of the present ecological zone locations.

Forests are interrelated with the other natural resources in ecological communities. Changes in forest cover affect all the other natural resources. Deforestation causes a loss of soil fertility, a change in soil physical properties, loss of wildlife habitat, loss of range and bush forage, increased water runoff and lowering of the water table, loss of wood supply and other gathered forest products, and reduced food security (bush meat, wild plants).

Forests can be divided by land ownership and use patterns into lands available to the population and lands reserved by the state. State reserved forest lands are further classified by use as protection and production forests within national forests. Wildlife protection is the major use of wildlife reservations, and protection of the ecosystem is the goal of national parks.

The Forest Service is charged with protecting and managing all forested lands in the country regardless of ownership or use. This goal is impossible in most developed countries and Chad is no exception. The level of management of national forests has been in the protection stage in Chad due to years of political insecurity. Some national forests have been encroached on to an extent that they are farms with no forest cover remaining (Ali 1993). There is a project to draw up management plans for the forests surrounding N'djaména, but for most of the country sufficient inventory data is unavailable for more intensive planning (Hecht 1993). The major forest products are fuelwood, rough construction wood, and roofing poles. Sawn wood and plywood are imported from CAR. Chad does not have a comparative advantage in industrial forest products.

A. Forest Management

A1. Local Management of Fuelwood

Recently, local communities have been recognized as land managers with their own territories. CARE in Sarh and CRD in Moundou are in the early stages of Participatory Rural Appraisal (PRA) information gathering in preparation of management plans for village territories. FAO has also been working with participatory village NRM.

120

Village territories are divided into fields, with field trees either residual from clearing or protected wildlings. Fields in the process of restoration (fallow) are covered with woody vegetation that restores fertility levels by fixing nitrogen and pumping nutrients from the lower strata of soil. This is maintained in the upper soil by the increase in organic material from litter and leaf fall. Much of the villages' needs for gathered material can be supplied from the fallow. When fallow is cleared, excess wood may be sold, if the village is within an urban wood shed—an area around a city that provides wood to meet urban needs, analagous to the "watershed," the area providing water flowing into a river or lake.

Forest land in reserve for future farming expansion is also part of the village territory. Village territory should also ideally contain land reserved as forest to supply village needs in wood and gathered products.

A2. Gathering

The importance of gathering in the village economy is often ignored, except for the gathering of fuelwood. Gathered products offer an opportunity to reduce economic risk. One of the most important functions of gathering is food supply. It is said that the grain comes from the field and the sauce comes from the forest. In times of crop failures gathered food can provide most of the diet. The consumption of Mikhet (*Boscia senegalensis*), Absabé (*Dactyloctenium aegypticum*), and Cram-cram (*Tribulus terrestris*), is a famine early warning indicator.

In addition to the directly consumed products, the forest is the village pharmacy, providing most known medicinal plants. Craft products such as mats and baskets made from materials gathered in the forest provide much of the income during the periods of labor surplus. Other gathered products also provide income to the rural household. Hamel (1988) lists 14 gathered food items sold during a visit to the N'djaména market. If forests are all converted to cultivated fields, farm incomes may increase over the short term, but as yields fall, income will fall and the economic diversification provided by gathering will no longer exist.

Two gathered products are important exports—karité butter and gum arabic. Karité butter is a major export in Mali and Burkina Faso but has not been developed in Chad due to preoccupation with war. Gum arabic is still traded but the world market is declining due to synthetic substitutes.

B. Impacts of ATPRP on Forests

B1. Introduction

Overuse and fire lead to degradation of the forest—reduction of stand volume (fewer and smaller stems) and loss of diversity (fewer species). Direct conversion to other use, however, causes total deforestation. This is usually a result of agricultural expansion or shifting cultivation and may be preceded by degradation. The richest forest in the country

(for production and composition) is also the forest with the most agricultural potential, and thus is most at risk.

The land management continuum varies from hunting and gathering to intensive production. The present system contains elements of the entire continuum. Household fuel and medicine and some foods are still gathered, while cotton is grown with purchased imported inputs. As population and land scarcity increase, forest will be converted through extensification of agriculture. The gathering also decreases and must be replaced by the production or purchase of formerly gathered products. Incursion into national forests or other reserved areas can occur if the state doesn't effectively control these areas.

If the intent of ATPRP is to increase agricultural output, then forested land is where agricultural expansion will occur. As there is no provision in the PAAD for local community management planning, forests will be converted to agricultural production.

B2. Intensive Production

If tariff changes result in increased agricultural output on currently cultivated land, this is agricultural intensification. Intensification involves an increased investment in capital (purchased inputs) or labor (organic soil amendments, agroforestry, soil and water conservation) or ideally a combination of both. Soil fertility can be maintained with chemical fertilizer over long periods only when combined with organic material (Pieri 1989). Intensification of production is the only option available to farmers in areas where land scarcity precludes fallow.

B3. Extensive Production

If the production increase is attributable to bringing uncultivated land into cultivation, this is agricultural extensification. This may be linked to overcoming a labor constraint; for example, when animal traction increases the efficiency of labor. This was the case when cotton culture was introduced with animal traction in Chad. This combination results in doubling the land farmed per farming unit (Pieri 1989). This expansion can only continue for as long as uncultivated land is available.

B4. Non-agricultural Impact

Commercial wood production can increase when transportation costs go down, extending the wood shed further into the countryside. The effect is forest degradation from unregulated cutting of natural forest. The PAAD assumes that road distance traveled will increase by 4.75 percent as a result of project intervention in the tariff policy structure. The cutting area for N'Djaména fuelwood supply is near the road. If a direct correlation is assumed between road distance and cut over forest, which appears to be the case, the ATPRP could cause a 9.72 percent increase in area deforested based on distance travelled from the city. See Figure 1 on the next page.

The fuelwood demand is divided into rural and urban. The rural fuelwood supply is gathered from natural forest stands and fallow lands. The urban fuelwood supply is commercialized. Wood cutters sell to transporters who sell to wholesalers and retailers. Madon (1992) estimated the annual consumption of N'Djamena is 200,879 tons of wood based on 1992 consumption surveys.

The major supply area is in the area south of N'Djamena to Bongor and West to the Logone River. This forest is mostly Sudanian open forest, and wooded savannah with typical stocking rates of 12 to 14 M^3/ha (Hamel 1988 and Maiga 1993). Typical savannah species wood weight is .8 ton/M^3 (Madon 1992).

The production area has had some planning activity from the FAO project that has been active in the area. This project has ended and a new project for increasing the level of management in this area is in the design phase. The Forêt de Mogroum (Figure 2) will be participatory managed and the population will receive benefits similar to the Guesselbodi model in Niger. The pilot phase will be 8,000 ha of forest. The eventual size will be 80,000 ha (Maiga 1993).

Figure 1. Additional land required for a 4.75 percent increase in wood production.

	Clear cut	unmanaged	managed	plantation
m^3	14	1.5	4.5	7
Tons/yr	11.20	1.20	3.60	5.60
Ha for 200,879 T annual consumption	18,000/yr 350,000/20 yr. rotation	167,000	56,000	36,000
4.75% increase	17,000	7,932	2,650	1,700

(Madon 1992, Kerkhof 1991, Hamel et al. 1988)

Figure 1 shows that as the level of management increases the amount of forest land impacted decreases. If one assumes the success of both the FAO and ATPRP projects, the amount of land under managed forest will exceed the amount required to produce fuelwood for N'Djaména by more than any access impact from transportation cost reductions from ATPRP. The additional market access for managed wood production will have a positive environmental impact.

C. Impact Indicators

The following questions will indicate the availability of natural forest products in the village:

- Where is wood gathered for fuel, house construction?
- Where are medicines gathered?

- Are fruits, yams or other wild foods gathered?
- Is bush meat available?
- Is there fallow?
- Where will new fields be cleared?
- Do villagers cook with crop residues?
- Are there field trees, and are they fruit or soil trees?
- Is there an interest in tree planting?

The following are sample village cases from the field trip showing indicators of both extensification and intensification of land use practices.

- **Djoit 3 Village near Moundou.** There was plenty of forest land freely available. Immigration was taking place. Land was farmed three years and new land cleared. Excess wood was burned.

- **Kol Village near Sarh.** Land was fallow for four years in the rotation after three year cultivation. There was natural forest near the village for gathering.

- **Doher Village near Moundou.** There was continuous cultivation with exhausted land being abandoned from low yields and striga. The women were hiking 15 km for fuel. Tree planting has been attempted. Construction wood was all purchased and imported from CAR.

- **Benoy Village near Moundou.** There is continuous cultivation with exhausted land abandoned. Limbs hacked from field trees are the only wood source. The village wants tree planting. Construction wood was purchased and imported from CAR.

D. Mitigation Plan

Although forests are a renewable resource, time and conditions may limit renewal. If the soil is lost by erosion, renewal of the forest communities is probably not possible. Extensive agricultural overuse of soils with or without fallow also limits renewal opportunities. Although fallow allows return of wood plants to the land, the original composition of the forest communities is lost.

If impact is assumed to occur as stated indirectly in the PAAD, the mitigation will be to lessen the impact or rationalize the forest use. This must take place before the impact or the resource will no longer exist and impact cannot be mitigated.

Impact will be lessened if trees and shrubs are included in the farming system to provide the formerly gathered products. This will partially substitute for the soil conservation and enrichment functions of fallow. This will have little effect on providing habitat for wildlife or forage for extensive livestock use. It can provide partial soil and water buffering if the vegetative cover is sufficient.

The ideal situation is for each village to have a management plan for their own territory and to have sufficient reserve for agricultural expansion while keeping sufficient forest reserve to allow continued gathering.

A program of participatory village resource management planning in those areas expected to be impacted should be done before ATPRP reforms go into effect. A program of increasing the productivity of existing agricultural land, using NRM techniques, should be done concurrently with the introduction of ATPRP reforms to reduce the amount of land needed for agricultural production increases.

E. Conclusions

Market reform funding should be balanced with rational production improvement activities to prevent resource allocation for short-term economic gain with no thought of long-term effects from damage to the resource base. If this project is successful in the present form, it could contribute to tropical deforestation.

APPENDIX C-1
REFERENCES

Ali, Mahamat 1993, personal communication.

Hamel, O. et al. 1988, *Conservation des Resources Naturelles et Développement Rural*, République du Tchad, Ministre du Plan et de la Coopération, N'Djaména.

Hecht, J. 1993, *Elaboration d'un Programme National de Connaissance et Suivi des Ressources Naturelles*, UNSO, N'Djaména.

Kerkhof, P. 1991, *L'Agroforestrie en Afrique*, Panos/ L'Harmattan, Paris.

Maiga, A. 1993, personal communication.

Madon, G. 1992, *Tchad. Eléments de Stratégie Energie Domestique Urbaine (Version Préliminaire)*, ESMAP Banque Mondiale, Washington.

Pieri, C. 1989, *Fertilité des terres de savanes*, CIRAD-IRAT, Paris.

ANNEX D

WATER
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ANNEX D
WATER

A. Introduction

Availability of water plays a critical role in agricultural productivity throughout the ATPRP impact area. Not only is it essential to export crops, forage isn't exported but it is almost always the limiting factor to production.

Chad is divided from south to north into the Sudanian, Sahelian, and Saharan agricultural production zones, based primarily on the decreasing amount of available water. The northern third of Chad, the Borkou/Ennedi/Tibesti (BET) region, has an unfavorable water balance resulting from increasingly sparse average annual rainfall and elevated evaporation rates. The harsh desert conditions, combined with a grossly inadequate transportation infrastructure, make it highly unlikely that this area will feel any impacts from ATPRP.

The Chari-Logone river system replenishes Lake Chad and is the water source for most of the irrigated agricultural production destined for the cash (and possibly export) market. Except for the initial flush of fecal matter following the first rains of each season and the high water sediment load, the river water quality is reputed to be excellent and has so far essentially escaped degradation by agricultural chemicals and industrial pollution. The impacts of the ATPRP on water quality, however, could be significant unless precautions are taken.

B. Dynamic Hydrologic Systems

B1. Rainfall and Condensation

The rainy season throughout Chad is unimodal, producing violently intense localized storms (75-150 mm/hr) with random and erratic distribution, occurring from June to October. The rainfall in the Saharan zone of the BET is less than 500 mm/year, rainfall in the northern portion of the Sahelian zone rarely exceeds 200 mm/year, while the southern portion of the zone sometimes receives as much as 700 mm. The Sudanian zone in the south averages between 1,000-1,400 mm/year.

The water balance is so critical in the northern deserts that morning dew (condensation) supplies the water necessary to support some wildlife species. Nevertheless, we are not aware of any attempt to quantify this moisture source, and we do not consider it significant enough to try to collect such data for purposes of the ATPRP.

B2. Evaporation and Transpiration

The ATPRP impact area has a hot period with the peak occurring in May, followed by the rainy season, and a second hot period beginning in October. N'Djaména has only about ten days per year when the sun does not shine, and with the thin atmosphere providing little protection from this massive influx of solar radiation, Chad literally bakes.

The mean annual evapotranspiration in the Saharan zone is listed as 2300 mm (91 in); in the Sahelian zone, 2200 mm (87 in); in the Sudanian zone, only 1900 mm (75 in). Although evaporation and transpiration rates are critical to the production of export crops, neither should be adversely affected by project unless the shade trees, forest, or existing cover crops are cleared; even then, such effects should be localized. Existing sources are able to provide this data, so the project will not need to collect it independently.

B3. Soil Moisture

Moisture held in the pores between grains of soil is vital to crop production in the rainfed and recessional agricultural systems. This topic is covered in the annex on agriculture and soils (Annex A).

B4. Watershed Basins

The Chad Basin, a structural depression since early tertiary time, is a huge endoreic watershed with its groundwater divide running through the Tibesti region of northern Chad, along the Sudan border in the Ouaddaï region to the east, through the Central African Republic, the Mandata mountains of Cameroon and the Guéra massif to the south, and west from the Jos plateau of Nigeria to beyond Gouré in Niger. The most significant feature is Lake Chad, which receives its water primarily from the Chari-Logone river system. Rising in the southern mountains, the Chari-Logone is the only perennial river in Chad. Many other ephemeral streams flow into the basin following heavy rainfall, but seldom for longer than a few hours. Other principal streams include the Batha in the Ouaddaï, the Bahr Salamat in the southeast, the Bahr Sala that rises in the south and is a tributary to the Chari, and the Mayo Kebbi, a tributary of the Benoué.

B5. Water Storage

Reservoirs and surface water storage areas are particularly susceptible to eutrophication caused by the enrichment of streams. Due to the extreme evaporation rate, however, very few surface storage reservoirs exist in Chad. In the Ouaddaï, for example, water is captured in the silt behind water control structures.

B6. Aquifers and Groundwater Recharge

The Chad basin formation, containing historically the most heavily exploited aquifers, has as recently as 1989 been divided into upper, middle, and lower zones respectively, named the quaternary, pliocene, and continental terminal. All hand-dug wells and 80 percent

of the boreholes tap the quartenary aquifer. These deposits are composed mainly of sand and clay varying from 30-100 m thick and contain an aquifer with interstitial porosity, which has fairly good recharge and extends over most of the country except the mountain regions of the extreme north. Two hydrogeological units are separated by a groundwater watershed that runs from Chittati, passes close to Ati, and ends at Abéché. The northern unit is recharged by seasonal streams, perennial rivers, area infiltration, and by draining the lowland depression, the Kanem, the Niger, and the BET aquifers; the southern is replenished by Lake Chad, the Chari, the Logone, and the Chari-Baguirmi horizon.

Mean annual recharge of the quaternary and pliocene aquifers, for the Chadian part of the geographic basin only, is estimated to be 3,600 million m^3/year. Exploitable groundwater reserves are estimated to range from 94,600,000 to 206,010,000 million m^3, an undetermined portion assumed to be fossil water.

The Chad Basin has two aquifer recharge zones: an external zone, consisting of the mountainous regions of the Hoggar, Ouaddaï, Dargour and related areas, and an internal zone, consisting of Chad Basin synclines where rainfall is heavy. Surface water from the Chari, the Logone, and other water courses, as well as directly from Lake Chad, provide good aquifer recharge. The "continental terminal" in Chad is of unknown thickness but is assumed to contain fossil waters.

B7. Flash Floods and Runoff

Locally intense rainfall events, combined with vast tracts of relatively impermeable land, create conditions susceptible to flash floods, accelerated soil erosion, and the transport of soil nutrients and pesticide residues over great distances. The unit hydrographs of most streams in the Chad Basin are characterized by low or non-existent base flows, a graph sharply peaked over a very short time, and a residual flow rapidly reducing to the pre-event base flow. This indicates that the absorptive capacity of the basins in Chad (including the replenishment of soil moisture, recharge of groundwater, and retention by plants and animals) is very low. Runoff is exacerbated by clearing cover vegetation and destroying the soil structure, triggering increased soil erosion and plug flow in the streams and tributaries.

B8. Lakes and Sinks

Lake Chad is the most important resource in the Chad Basin. There are, however, six other lakes of some importance: Lake Fitri, with a catchment of 1,300 sq km, is a proposed biosphere reserve fed by the Batha river. Lake Iro in Moyen-Chari, with a catchment of 455 sq km, is fed by the crest waters of the Bahr Asoum; Lake Léré is fed by the Mayo Kebbi; and Lakes Tikem and Fiangat are fed by the Kabia (Tikem-Sianga). Many other ephemeral streams disappear into the sands of the desert or the perched water table of a wadi, or evaporate rapidly in the hot dry air.

C. Water Quantity

C1. Rainfall Gauging Stations

Rainfall gauging stations exist throughout Chad. A network composed of 137 rainfall gauging stations, 7 weather stations, 27 agricultural condition stations is operated by the Direction des Ressources en Eau et de la Météorologie (DREM) and 20 synoptic stations managed by the Agence pour la Sécurité de la Navigation en Afrique et à Madagascar (ASECNA). Records are stored in a database management system, and decadal data are published periodically in the AGRHYMET bulletin. The USAID-funded Famine Early Warning System (FEWS) also reports rainfall data on a monthly basis for the Sahelian zone.

C2. Surface Water Gauging Stations

River water depth in Chad is recorded at 58 DREM stations. Gauging is also done manually at most bridges and ferry crossings, permitting a comparison of runoff with rainfall records.

C3. Aquifer Productivity

The pliocene-quaternary aquifer provides yields of 2.5 l/sec, while boreholes tapping the continental terminal produce an average yield of 27.7 l/sec. Productivity has been estimated at 20 m^3/day from a traditional well in a granitic area, 40 m^3/day from a cement well in a sedimentary area, and 400 m^3/day from a borehole.

The Bureau de l'Eau of the Direction de l'Hydraulique et de l'Assainissement, Ministère des Mines, de l'Energie, et des Ressources en Eau (MMERE), measured and recorded the water levels in approximately 200 wells in the Kanem, Batha, Salamat, and prefectures in the south, to determine trends in water surface elevations. The report, published in August 1992, revealed no long-term variation in water levels.

C4. Irrigation Demand

Based on historical data, a hectare of land in Chad requires approximately 24,000 m^3 of irrigation water each year. Areas by region suitable for irrigation are as follows:

Lac	60,000 ha
Kanem	5,000
Assale	13,000
Ouaddai	1,000
Batha	20,000
Bahr Azoum	200,000
Chari	163,000
Logone	200,000
TOTAL	662,000 ha

Crops for large-scale production might include rice, wheat, and sugar cane. Currently, small cooperative rice irrigation schemes exist between Bongor and Lai on the Logone, rice and vegetable irrigation on the banks of the Chari north of N'Djamena, and

small-scale vegetable irrigation in Kanem and Ouddaï. Irrigation is also used to grow sugar cane at the plantation in Banda.

C5. Other Major Users

The supply of water to urban areas in Chad is obtained from boreholes most commonly tapping the regional groundwater aquifer. Cities supplied with water from boreholes include N'Djaména, Sahr, Moundou, Abéché, Pala, Mao, Kélo, Koumra, Doba, Moussoro, and Fianga. Urban consumption has been estimated at 40 l/day per inhabitant.

Industrial uses of water include the Gala Brewery at Moundou, the Banda sugar mill, and the mills of CotonTchad. Their combined water requirement was estimated at 13,000 m^3/day, or 5 million cu m/year.

Livestock average daily consumption of water is estimated to be 20 l/head of cattle, 5 l/head of sheep or goats, and 35 l/head of camel. According to a document prepared by the Inter-African Committee for Hydraulic Studies entitled "Utilization of water resources and land in the savannah regions," the number of livestock is expected to stabilize at 5 million head of cattle, 10 million head of sheep and goats, and 600,000 camels, for a total water consumption of 62,415 million l/year.

D. Water Quality

D1. Sedimentation

Soil erosion caused by water flow—whether sheet, rill or gully erosion—results in the suspension and transport of soil particles in streams and rivers. The discharge into Lake Chad varies from 2 to 2.6 million tons per year; this sediment load can be a powerful indicator of unsound land use practices.

The relative magnitude of the problem can be determined with a simple test for settlable solids. Although intense storms can cause abnormally large sediment loads, this test could be used to show, for instance, that the Chari watershed basin is losing its vegetative cover more rapidly than the Logone (or vice versa). It will not easily show, however, the impact of the ATPRP as distinct from normal highwater effects and those brought about by other causes, such as an increase in population.

D2. Nutrient Enrichment

The addition of chemical fertilizer (nitrogen/phosphorus/potassium, or NPK) to agricultural cash crops helps farmers maximize production where land and labor are at a premium, as is increasingly the case in Chad. Farmers in the ATPRP impact area are already familiar with the benefits of chemical fertilizer through their participation in the CotonTchad input program. Chemical fertilizer is also currently used by rice cooperatives and donor-assisted vegetable production projects.

142

Chemical fertilizer washed from the land into a body of water is a powerful growth stimulus for aquatic plants, causing rapid multiplication and creating an enormous flush of vegetative biomass, accompanied by a corresponding increase in microbiological life forms. Many aerobic forms of life, using the dissolved oxygen in the water, have an adverse impact on fish and other higher forms of aquatic life in a process called eutrophication.

Chemical testing of river and lake waters for NPK or chlorophyll would serve as an alert to indicate whether this non-point source enrichment is taking place, before the lakes become eutrophic. Nitrogen in drinking water (such as well water) can cause "blue babies," a major threat in areas using chemical fertilizers.

D3. Pesticide Contamination

One component of an integrated pest management program involves the use of selected pesticides. In today's health- and environmentally-conscious world, both persistent pesticides and those that tend to bioaccumulate, are banned in most countries. But even pesticides considered less hazardous vary in their toxicity and selectivity, and can become dangerous if transported from the prescribed contact point. Runoff water can be a significant vehicle to transport and concentrate pesticides. Moreover, pesticides that are normally readily degradable can become persistent if transported into groundwater away from the powerful breakdown effects of sunlight, heat, and atmospheric oxygen. This is particularly hazardous to aquatic life, which is hypersensitive to certain types of pesticides even in minute amounts.

D4. Sanitary Wastewater

No municipal wastewater collection systems currently exist in Chad. Advanced facilities and residences have septic tanks and either a soak pit or a leach field system; long drop pit privies are sometimes used, but the most common practice is random open air defecation.

D5. Industrial Pollution

Chad has very few industrial plants or factories, and thus virtually no problems associated with effluent outfalls of noxious, toxic, or heavily enriched washwaters. Nutrient enrichment often results from sugar production such as practiced by the Banda sugar mill. The brewery and CotonTchad discharge wastes of unknown consistency.

D6. Water Quality Standards

Chad has adopted the World Health Organization water quality standards but testing and enforcement are non-existent.

E. Influence of ATPRP

Short-term impacts. The ATPRP will have no direct impacts on water supply. However, the project could have short-term (five year) impacts on water quality in several ways: localized increases in sediment loads (removal of cover), localized contamination of wells with agricultural chemicals (increase in input use), and a localized increase in non-point source pollution (runoff of herbicide or insecticide).

Long-term impacts. The long-term (5-20 year) impact of the program could include increased runoff peaks (removal of ground cover), decreased base flows (removal of organics), decreased surface water quantity (irrigation increase), localized depletion of groundwater (well irrigation), nitrate contamination of groundwater (fertilizer use), eutrophication in lakes (fertilizer use), contamination of well water (pesticide use), poisoning of surface water (pesticide runoff, pesticide fishing, and hydrocarbon spills), and lowering of the water table (decreased shade and organics).

Cumulative impacts. Widespread use of fertilizers and pesticides (herbicides and insecticides) could have a cumulative effect on the quality of water in wells, rivers and lakes, and extensive adoption of pumped irrigation could lower groundwater tables and dry up streams in localized areas or watershed basins. Increased pumping and expanded use of trucks could also raise contamination of water sources by hydrocarbons.

Delayed impacts. If surface water in an area of groundwater recharge dries up or becomes contaminated, similar effects could be felt by groundwater, water wells, and boreholes within the aquifer. Pumping fossil water for irrigation purposes could permanently impact this non-renewable resource.

F. Monitoring

F1. Data Needs

The ATPRP program does not need to supplement the collection of data on the quantity of water in Chad, since measurements of rainfall, stream flow, and well surface elevation are adequate. Moreover, numerous studies have been undertaken on the impact of current demand on groundwater resources. While the vagaries of climate cycles are insufficiently understood, this falls beyond the purview of ATPRP.

Monitoring the quality of drinking water ensures that it is free from water-borne disease organisms—bacterial, microbial, and viral. Contamination of water by fecal material is the main source of disease transmission; the main tests for determining if such contamination is present are the fecal coliform, total coliform, and the biochemical oxygen demand (BOD 5) tests. ATPRP is not likely to affect the sanitary quality of drinking water sources or wells, so it does not call for such monitoring.

Water must also be free from water-washed diseases such as schistosomiasis (*Schistosoma hematobium*) and Guinea worm. ATPRP reforms encourage only small-scale

gardening, irrigated with well water and pumped surface water. Ground water from a well should be free from water-washed disease; in addition, the pressure created by pumped irrigation is sufficient to kill the cercaria, thereby eliminating the threat of diseases it carries.

Vectors are likely to be introduced only if water weeds are allowed to become established and provide the appropriate habitat.

Water contact diseases such as onchocercosis and malaria should not be affected by ATPRP reforms. The program is unlikely to create new black fly habitat or increase the exposure of villagers to these vectors. Irrigated agriculture outside the rainy season would marginally increase the habitat for mosquito breeding; however, intermittent pumping means that the conditions necessary for mosquitoes to mature will not exist.

Historical precedent suggests the unlikelihood that farmers will use chemical fertilizers, even if available, except on cash crops. Should NPK ever be used, however, area wells used for domestic drinking water should be monitored for nitrogen.

Non-point source fertilizer enrichment of surface water is another possibility if farmers use chemical fertilizer. The fact that potassium is mostly absent in the natural environment in Chad would make this a likely candidate for monitoring to flat nutrient enrichment in lakes and rivers. On the other hand, since wells should be tested for nitrogen, to be consistent, surface water should be tested for this element. Certainly a baseline should be established since fertilizer has been used by CotonTchad for many years, probably already imparting a characteristic signature.

Farmers would use pesticides—primarily herbicides and secondarily insecticides—if available, as they have historically done on cotton and against specific target pests such as locusts, termites, thrips, and nematodes. During the rainy season, irrigation return flows are wasted to surface water courses. Considering the quantity of wet weather streamflow, we are assuming that this does not currently constitute a problem. In any case, it is probably not measurable.

F2. Quality Parameters and Impact Indicators

Chemical fertilizer can result in well contamination. Nitrogen in drinking water can cause a condition in infants known as "blue baby" disease; to avoid this problem, nitrate nitrogen in well water should be kept below the threshold level of 45 mg/l. Selected wells in areas where chemical fertilizer has been used historically could provide a signature and indicate the level of the threat. (See the protocol, Appendix D-1, for methods of testing for nitrates).

Surface water testing for NPK enrichment should be done at several points in the annual cycle: low water, first flush, periodically during the fertilizer runoff season leading to peak flow, and at peak water flow. Testing should be done at normal sites where testing or gauging is currently undertaken if possible, and the major basins of the Chari and Logone certainly should be included, especially at the last gauging station nearest their confluence.

A series of tests should also be conducted for the baseline storm event pesticide chemograph signature in Lake Chad, the Chari, and the Logone. Pesticide monitoring by the program should mirror imports of pesticides by the formal sector as well as anticipated

146

clandestine imports by the parallel market. A key determinant would be the amount of various types of pesticides imported officially.

APPENDIX D-1
WATER QUALITY MONITORING PROTOCOL

Physical Indicators:

Temperature	Degrees C	Normal 25 - 33
Color (Discoloration)	Hazen Units	Less than 15
Odor	T.O.V.	Less than 3
Turbidity	T.U.	Less than 5
pH	pH Units	Normal 5.5 - 8.5
Dissolved Oxygen	mg/l	Average not less than 4.0
Electrical Conductivity	Micromhos/cm	less than 0.75
Salinity	mg/kg	less than 200

T.O.V. = Threshold Odor Value
T.U. = Turbidity Unit

Chemical Indicators:

Total Dissolved Solids	mg/l	(Max Limit)	500
Nitrate Nitrogen (NO_3)	mg/l		45
Ammonia Nitrogen	mg/l	(Threshold LC50)	0.2
Phosphate Phosphorus (PO_4)	mg/l		5.0
Sulfides (Sulfate SO_4)	mg/l		250
Suspended Solids	mg/l		30
Total Potassium	mg/l		
Chlorinated Hydrocarbons	mg/l		

Biological Indicators:

Total Coliforms	Positive/Month		Less than 10%
Fecal Coliforms (E. coli)	MPN/ml	(Max limit)	50/100ml
BOD (5 day/20° C)	mg/kg	(Max limit)	2 mg/kg
COD (Industrial Wastes)	mg/l		
Algae/Microorganisms	Count/l		

Nitrates Sampling:

Monthly intervals for a two-year period. Usually about 15 ml of water is required for one nitrate test, so sampling should take 30 ml to have a control or back-up. Polyethylene

sample containers are appropriate. Samples should be stored at refrigerator temperature (approximately 4° C), and should be analyzed within 30 days. U.S. laboratories charge about $10 per sample.

Pesticides Sampling:

Sampling should be done 15 days after the first application, and subsequently monthly, ending 15-30 days after the last application. A sample of 300 ml is needed, so 600 ml should be taken to provide a back-up. Glass containers must be used for a single test (canning jars are sturdy and work well); the lid should be lined with two layers of household aluminum foil to keep the lid from touching the water sample. Samples should be kept cool between collection and analysis, and analyzed within 60 days. U.S. laboratories charge about $100 per sample.

APPENDIX D-2
BIBLIOGRAPHY

Department of Technical Cooperation for Development and Economic Commission for Africa, Ground Water in North and West Africa, Natural Resources/Water Series No 18, United Nations, New York, 1988.

Eberschweiler, Christian, Impact Hydrologique et Ecologique de l'exploitation des eaux souterraines à des fins agricoles dans la région des ouadis au nord-est du lac Tchad: quelques aspects, Projet ORT au Tchad, USAID Tchad, Juillet 1990.

ANNEX E

WILDLIFE CONSIDERATIONS

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ANNEX E
WILDLIFE CONSIDERATIONS

A. Introduction

The goal of ATPRP is to increase market-oriented agricultural production. This will be accomplished by reducing tariffs on agricultural inputs, trucks, and spare parts, and reducing taxes on agricultural exports and internal shipping. These changes will reduce costs to farmers, herders, and wood transporters and are expected to increase their productivity and income. Such stimulation, coupled with anticipated increases in export markets, will probably result in the conversion of additional land to agriculture and intensified management of land now in crop production. This would reduce the area of land currently used for grazing, forest production, and as habitat for wildlife. With more intensive farming, the use of water, fertilizers, herbicides, and insecticides may increase. If these changes occur, they would increase hazards to wildlife, fish, livestock, and humans from pesticide toxicity; increase pest problems; decrease the quantity and quality of underground and downstream water; and reduce the ability of agricultural lands and affected habitats elsewhere to support fish and wildlife.

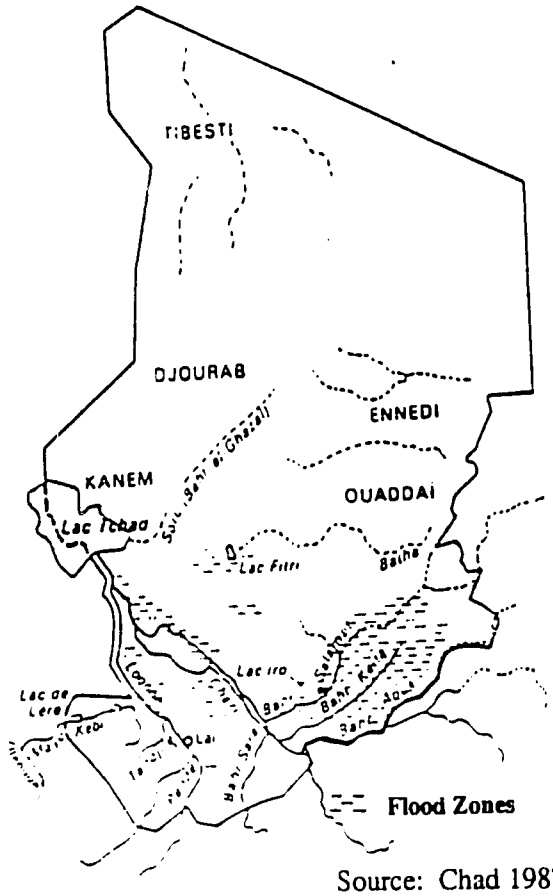
An Initial Environmental Evaluation of ATPRP prepared by USAID (1992) concluded that the project would not adversely affect the environment. This annex expands on the possible effects of ATPRP on wildlife and proposes monitoring activities to track those impacts. This annex will primarily consider impacts on vertebrate species. Most discussion will be about birds and mammals, but some consideration will be given to fish and commercial fisheries. Note that the term "wildlife" is used for all vertebrates.

Most of Chad's population lives in the southern half of the country. The increased agricultural activity caused by ATPRP is expected to be greatest in the five southern provinces where rainfall is the highest (>900 mm), but also in the drier areas between the Lac and Ouaddaï provinces, which produce crops and are closest to domestic and export markets. The vegetation in the project area is Sudanian and Guinean savannah, in which there are extensive flood plains of rivers that drain the southern part of the country. Major drainages are the Chari, Logone, Mayo Kebbi, and Batha rivers. Each of these basins has unique characteristics and contains fish and wildlife habitats that could be impacted by ATPRP-generated activities.

Of the three watersheds that dominate the project area (see Map E-1 on the following page) the Chari and Logone rivers are the longest and carry the most water. These two rivers provide more than 95 percent of the surface water that flows into Lake Chad (Wanzie 1990). The Mayo-Kebbi River system in the south includes several lakes, including Lake Léré, before the river leaves Chad and enters Cameroon. The Batha is an intermittent river that drains eastern Chad and empties into Lake Fitri. The basins within these watersheds could

152

Map E-1: The Rivers and Lakes of Chad



Source: Chad 1987

all be affected by project-stimulated activities. Upland, wetland, riverine, and lake habitats used by wildlife could be polluted and degraded by anticipated changes in land-use practice.

Natural vegetation within the project area has been changed by human activities. Most land has been farmed; however, much of it is fallow at any given time. Remaining areas have been grazed and a large proportion of the trees have been cut for firewood. There is very little pristine vegetation remaining, but many areas have the potential to improve and recover some of their original vegetative cover and composition. Within the project area this potential is greatest at sites outside of the southern provinces where past land use has not been as intense or widespread.

Due to the intensity of land use within the project area, few ostriches (*Struthio camelus*), crocodiles (*Crocydylus niloticus*), and larger mammals remain. Deterioration of their habitat, hunting, and other human pressures make it unlikely that those species can exist in the area. Attempts should be made to protect and preserve these larger animals at other more isolated and pristine sites outside of the project area. Considerable land is available for this purpose. This annex will primarily consider impacts on vulnerable species that reside within the project area or use it during their annual migrations.

ATPRP will result in more land being farmed and intensely managed to maximize agricultural production. These activities will have an adverse effect on wildlife. The native flora and fauna of all areas have developed over time to fully utilize the energy that is available to support life. Humans as hunters and gatherers harvested native plants and

animals for food and were themselves a natural part of the diversity within the ecosystem. With the advent of agriculture and livestock, humans began to manage land and animals for their exclusive consumption. This process ultimately reduced the area, energy, and resources remaining to support native plants and animals. Agriculture can always be expected to reduce biodiversity and the carrying capacity for most species of wildlife. A few species of animals and plants actually benefit from conversion to agriculture; however, these organisms usually come to be regarded as pests (weeds, insects, rodents, and birds). As the intensity of land management for agriculture increases, plant and animal diversity continues to diminish until only a simple, unstable system of soil, air, water, crops, and crop pests remains. Such an ecosystem can be maintained temporarily with fertilizers and pesticides, but as evident with agriculture in the United States, it cannot be indefinitely sustained.

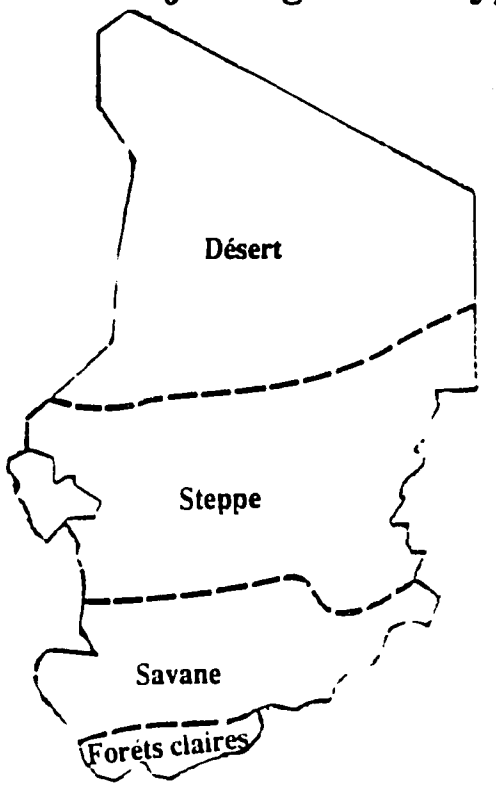
Ecosystems must contain a high degree of diversity to be stable and sustainable (WRI 1992). The checks and balances needed for stability are provided by the competition between organisms and the regulation of their numbers by their predators and parasites. Complex ecosystems are more likely to be stable, while simple ecosystems often are not. ATPRP-stimulated activities will tend to reduce biodiversity and thus to reduce stability in Chadian agriculture. The simple, sustenance farming practiced today in Chad is, ecologically, a more stable and sustainable activity. However, it is less productive in the short-term than more intensive farming and produces little profit for farmers. Population growth in Chad demands increases in food production and agricultural profits. These goals can be temporarily attained through the extensification and intensification of agriculture. Therefore, those activities will occur, supported by the influences of ATPRP.

B. Description of Principal Habitats and Associated Wildlife in the Project Area

As noted earlier, the ATPRP is most likely to impact the southern third of Chad. This area was termed "Tchad utile" during the French colonial period, as that is where the rainfall was high enough for arable cultivation. The northern limit of this region is approximately the 400 mm isohyet, and lies south of a line connecting Massakory (south-east of Lake Chad) with Abéché.

In order to refer to the various biotic zones and associated fauna and flora in Chad, it is necessary to name each of the major biomes. Various classifications and sets of nomenclature have been developed. One classification (Tchad, 1987) uses the terms *Désert, Steppe, Savane, Fôrets claires,* (desert, steppe, savannah, open forest) in descending order from north to south (Map E-2, on the following page) to describe the countryside. Another (Tchad, 1987) divides Chad into three climatic zones: Desert, Sahelian, and Tropical (Map E-3, found on page E-5). The most widely used classification for the North African vegetation zones is Saharan, Sahelian, Sudanian, and Guinean. In some cases, these zones are further subdivided by linking the names of the preceding or succeeding zone to the each of these categories (Pias, 1970; Kindler et al., 1989). A slightly modified version of this classification is set out as in Table E-1, together with corresponding amounts of rainfall (Map E-4, found on page E-5).

Map E-2: The Major Vegetation Types of Chad



Source: Chad 1987

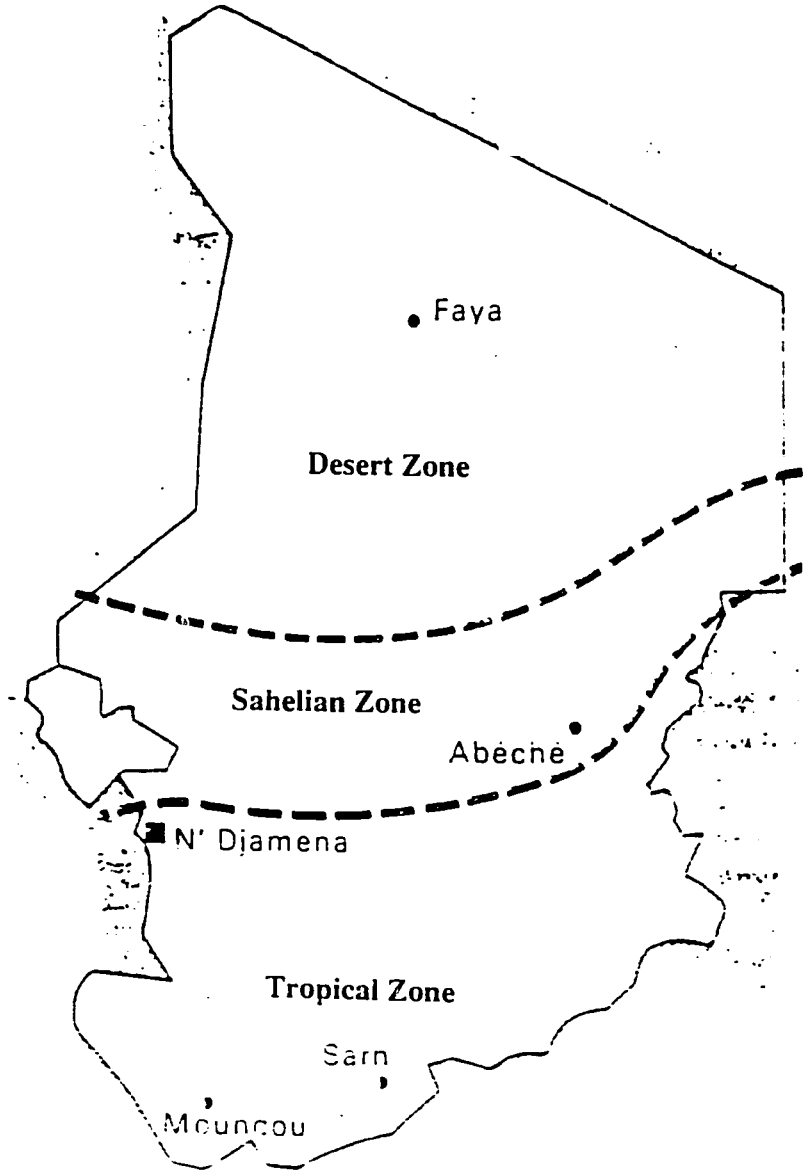
Table E-1 - North African Vegetation Zones

Rainfall	Designation	Category
1. Under 50 mm	Saharan	Desert
2. 50-200 mm	Sahelo-Saharan	Sub-desert steppe
3. 200-400 mm	Saharo-Sahelian	Grass/shrub steppe
4. 400-600 mm	Sudano-Sahelian	Thorny open savannah
5. 600-800 mm	Sahelo-Sudanian	Mixed dense savannah
6. 800-1000 mm	Guineo-Sudanian	Woodland savannah
7. 1000-1200 mm	Sudano-Guinean	Deciduous open forest
8. 1200-1500 mm	Guinean	Deciduous dense forest

All of these designations are based on visual or measurable parameters, such as the dominant species of trees and shrubs, vegetation type (open grassland, shrub savannah, tree savannah, closed forest, etc.), rainfall, climatic characteristics, edaphic (soil) features, etc.

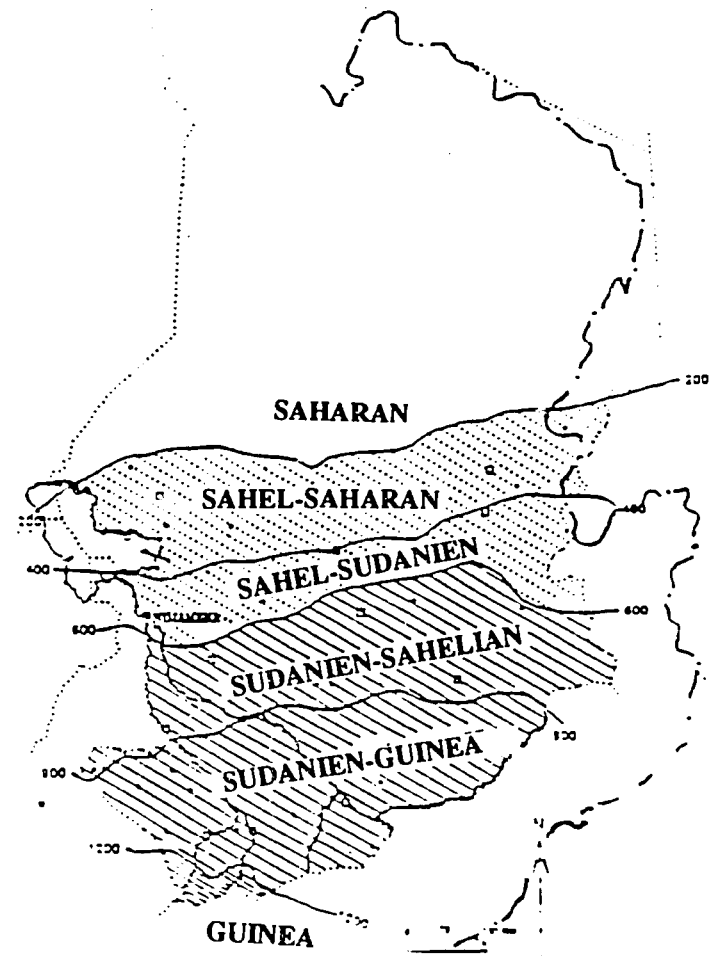
Not only are these biotic zones normally characterizable in terms of species of wildlife found, they may also be characterized to a large extent by the forms of land use and the population density they can sustain. However, plotting where their boundaries lie is a difficult task in a very flat country like Chad, because one zone gradually merges into the next. The distinction is further blurred by the mosaic of seasonally flooded heavy soils. Also, the change in rainfall over the past 50 years has shifted the calculated isohyet

Map E-3: The Climatic Zones of Chad



Source: Chad 1987

Map E-4: The Bioclimatic zones of Chad



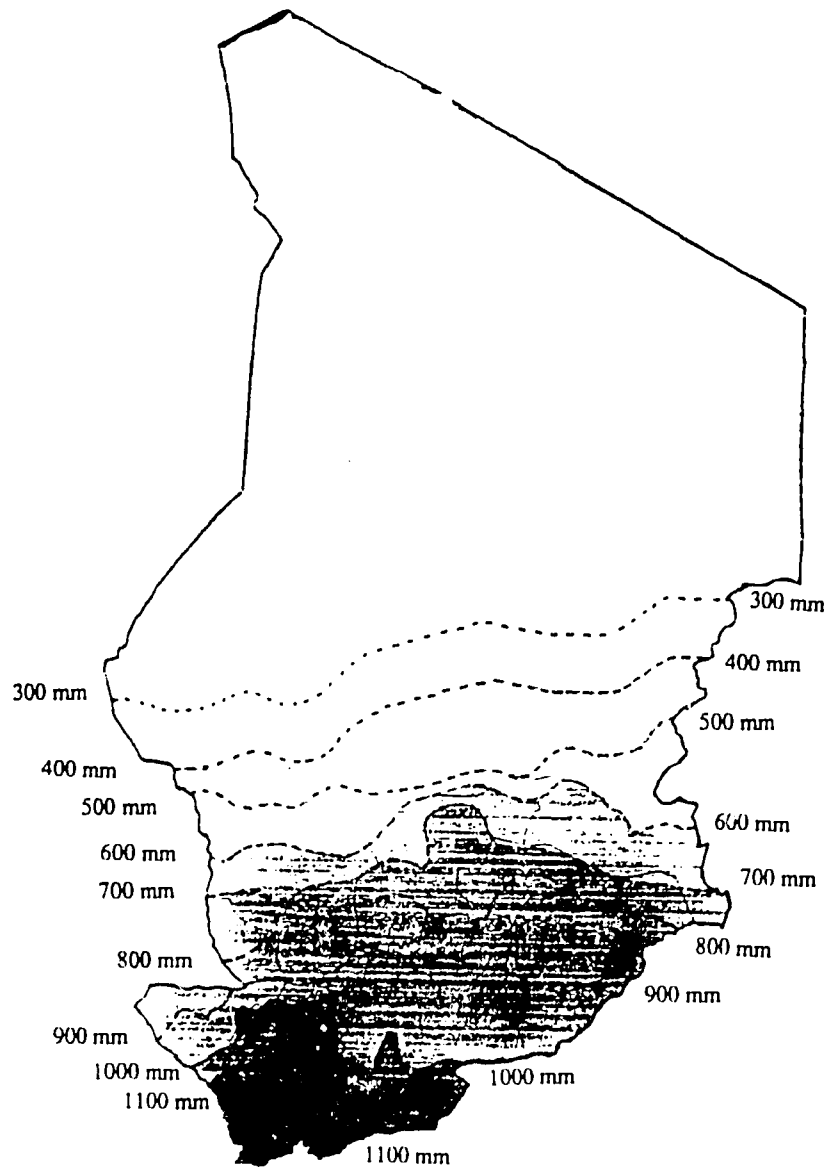
Source: LCBC Report 1989

positions, and it appears from the current meteorological data that the 1200 mm isohyet now lies south of Chad, effectively eliminating the Guinean zone from this country (Map E-5, below). Other isohyets appear to have moved 120-200 km south of their previously plotted positions in the past 30 years (F. Lee, FEWS, Chad, personal communication).

The very detailed vegetation map of Chad (Pias 1970) should be an optimum basis for delineating vegetation zones, but on the two field trips undertaken by this team, what appeared on the ground was often different from the map. This may be due in part to human and climatic influences since the map was compiled. As the verification of egetation zones and their boundaries was not practicable because most of the trees were leafless at this time of year and because of lack of time, a looser classification is used in this report.

The following subsections describe the various biotic zones of the region where ATPRP is likely to have an impact.

Map E-5: Republic of Chad Average Cumulative Annual Rainfall 1951-1980



Source: GRT/DREM; CILSS/Agrhymet

159

B1. Savannah

B1a. The Tropical (Sudanian) Savannah South of the Chari River

There is almost no terrain south of the Chari River that has not been utilized and modified by people and livestock; pristine habitat, including in the parks and reserves, amounted to perhaps 1 percent of the total. The intensity of use appears correlated with population density, and is greatest in the vicinity of permanent water (rivers) and major roads. Usage is least in areas of poor soils (between Pala and Léré in the southwest corner of the project area), and in areas subject to temporary inundation (the floodplain between Bongor and Eré). Human impact is also reported as being low in much of the Salamat. Population pressures are heaviest in the vicinity of the major towns.

The natural climax vegetation south of the 500 mm isohyet is savannah woodland. The density and heights of trees increase towards the south and the border of the Central African Republic, in conformity with the increasing rainfall and greater humidity. In the Sahelo-Sudanian savannah, the woodland is dominated by thorny *Acacia* spp., with *A. seyal* on wetter sites, together with *Balanites aegyptiaca*, *Ziziphus spina-christii*, *Piliostigma reticulata*, *Sclerocarya birrea*, *Combretum* spp., *Terminalia* spp., and with patches of Doum Palm (*Hyphaene thebaica*). The thorny components largely disappear in the Sudano-Guinean vegetation zone, where the rainfall exceeds 900 mm. Oddly, the vegetation map of ORSTOM (1964) makes no distinction between these two zones in the area between Sarh and N'Djaména.

Most of the savannah zone has been heavily grazed, and annual species (*Eragrostis tremula* and *Aristida* spp.) now comprise much of the grass cover, especially in the drier Sahelian zone in the north. *Calotropis procera* is a common shrub on disturbed sites, and *Guiera senegalensis* replaces it on fallow sandy loams in the south.

The bulk of the savannah zone has been cropped for sorghum and millet, and is currently in various age categories of fallow, with the more tenacious trees and shrubs regrowing from roots and stumps. Crop yields in this area would be too low in the drier north to justify the use of fertilizers, but these would be desirable in the better rainfall areas, particularly nitrogenous and phosphatic forms. Cotton is widely grown in the southern part of the Sudanian savannah zone, and CotonTchad supplies fertilizers and pesticides as part of a package of inputs to all growers. More than 95 percent of the savannah zone appears to be on very level ground (the bed and deltas of the former palaeo-Lake Chad). Consequently storm run-off will be limited, especially on the more sandy soils, and the quantity of agrochemical runoff is likely to be minimal.

The mosaic of small geological formations between Pala and Léré suggests that there should be a corresponding mosaic of associated ecosystems. If so, these were not apparent on casual inspection. However, this area differed from others on the tour in that it comprised low hills and rolling terrain with broad shallow valleys and open grassland on infertile shallow soils. It is highly likely that this corner of the country will contain items of fauna and flora unique to Chad, and it deserves much additional study. It is only the

intensively cultivated floodplain along the Mayo-Kebbi River near Léré that is likely to be impacted by the ATPRP project, as the succession of high-yielding crops invites the use of agrochemicals. The presence of the landlocked relic population of manatees (*Trichecus senegalensis*) in Lakes Léré and Tréné requires that extra caution be exercised in the use of the surrounding croplands and grazing areas. Large numbers of cattle also come to drink at these lakes.

B1b. The Sahelian Savannah

In the area from N'Djaména to Abéché via Bitkine and Mongo in the Guéra hills, cultivation is more limited because of the drier climate and sparser population. Nevertheless, the area northwest of N'Djaména for about 150 km towards Ngoura has been almost entirely deforested (except for some tree protection in the Bas-Chari Fauna Reserve between N'Djaména and Douggia), and is all under cultivation or short-term fallow. In addition, the sand sheets between Lake Fitri, Ati, Oum-Hadjer, and Abéché (which appeared to be open grassland from the air) were found to have been cleared of bush, utilized for millet production and dominated by *Eragrostis tremula*.

Similarly, the lighter soils derived in part from granite and gneiss in the Guéra hills were largely under crops or fallow, but some heavy soils were also in use due to more favorable precipitation and greater population pressures. Where relatively undisturbed, the more sandy Guéra soils supported species such as *Piliostigma reticulata*, *Albizia* spp., and *Eragrostis tremula*, and on the clay patches *Acacia seyal* and *Balanites aegyptiaca* were dominant; large fig trees (*Ficus* spp.) occurred along watercourses. The gum acacia (*Acacia senegalensis*) was only seen very sparingly throughout the Guéra/Abéché area, always on sandy soil.

North of the 500 mm isohyet, which extends from N'Djaména via Lake Fitri to Abéché, the woodland becomes progressively less dense and more shrubby, especially on better drained soils, and grades into typical Sahelian scattered *acacia/balanites* thorny savannah, with short annual and perennial grasses, and shrubs such as *Boscia senegalensis*, *Gueira senegalensis* (often dense on fallows), *Capparis decidua* (*C. aphylla*), and *Maerua crassifolia*. The heavier seasonally wet soils (silty clay loams and clays) with *Acacia seyal* and *Balanites aegyptiaca* were largely uncultivated in this northern sector.

B2. Forests

B2a. Deciduous Woodland

No evergreen closed canopy or gallery forests were encountered, but some of the woodland in Manda National Park, areas between Sarh and Kyabé, and between Sarh and Doba, comprised a dense mix of large trees, together with smaller trees and shrubs, that probably conform to the French classification *"Forêts claires."* Manda is one of two forest reserves seen (Djoli-Kera), the other being at Pala (Yamba-Bereté). The Pola reserve was of an even more open aspect in drier terrain, with *Isoberlinia doka* a common component. The wetter woodland areas had varying amounts of *Anogeissus leiocarpus*, *Parkia biglobosa*,

159

Khaya senegalensis, *Combretum* spp., and *Terminalia* spp. Grass is present throughout, and is subject to periodic burning. The vegetation map of Chad (Pias 1970) shows much of the area south of a line between Pala and Kyabé as Sudano-Guinean savannah forest containing various tropical species, including oil palms (*Elaeis guineensis*), but if these palms are present, they must be well south of the Sarh-Moundou road, as none of the area traversed appeared to be sufficiently tropical to support them.

The former stands of Borassus Palm (*Borassus aethiopum*) along the Chari and Logone from Lake Chad south to Bongor have all been cut for construction timber, principally for sale in N'Djaména. Not even the female palms (whose timber is inferior, and which are required for reseeding), have been spared.

According to one vegetation map of Chad (Pias 1970), the African Bamboo *(Oxytenanthera abyssinica)* grows in the southern tip of Chad on either side of Baibokum in the area of the country's highest rainfall, and also in patches south of Sarh. A small isolated stand occurs further north near Neillim.

B2b. Riparian Forests

Along river banks and in damp watercourses, higher soil moisture and fertility supports a more luxuriant vegetation than is possible in the surrounding countryside. These strips of forest are usually very narrow, often not wider than the span of the crowns of two or three trees, except in floodplain situations. The tree species are different from those in the adjacent woodlands or savannah, and they are taller and more closely spaced, usually forming a closed evergreen canopy with a minimum of understory herbs. Because of the factors that enable them to grow in these sites, they will usually be the only representatives of their species in that area. They provide, therefore, the only habitat for particular species of birds, butterflies and other insects, mammals, and reptiles that depend on them for food, breeding ground, or shelter. In addition, riparian forests are often an important source of medicinal plants or fruits to the local villagers. Riparian forests help protect river banks from flood erosion, and as they are valuable for rest and recreation, their importance is disproportionate to their size. In the drier northern part of Chad, the wadi beds also sustain such riparian forests, providing resting and feeding sites for migrant birds facing trans-Saharan flights in the Ouadi Rime-Ouadi Achime Faunal Reserve (Newby 1979/80).

It is therefore essential that riparian forests be given the greatest measure of protection. A possible impact from ATPRP would be increased logging of the larger trees or extending gardens in these fertile wet soils. Education of the rural populace and better surveillance by the wide network of forestry staff will be required to ensure that these important resources are used on a sustainable basis, and are not over-exploited for short-term gains. It would also be desirable for the GOC to enact legislation similar to Zimbabwe's Streambank Cultivation Regulations under the Natural Resources Act, which controls the usage of land adjacent to rivers and in waterways.

160

B3. Arable Lands

B3a. Southern Savannah Area

With the exception of cotton and manioc fields, it was often difficult to determine if a piece of land had been cropped in the past season, because of the amount of weed and coppice growth. Animal draft is now widely used for land preparation, but much is still done by hand. Roots and stumps abound in most fields, which expedites bush fallow, provides protection against sun, wind, and rain, and promotes recycling of nutrients from deeper levels. Selected large trees are left intact, usually for fruit or seeds (*Khaya senegalensis*, *Ficus* spp., *Parkia biglobosa*, *Butyrospermum parkii*, *Balanites aegyptiaca*), creating what are known as "parks" (Seignobis 1979), or are lopped if required for livestock forage. Apart from cotton, the principal crops are sorghum on heavier soils (millet on dry or sandy sites), groundnuts, and cowpeas (or other legumes), augmented with manioc (cassava) in the higher rainfall areas. Rice is grown on floodplains, as is taro between Eré and Bongor. Mango trees dominate the villages, but little other fruit is grown.

In the N'Djaména/Sarh/Kyabé/Moundou/Pala/Léré/Eré/Bongor/N'Djaména circuit that was made 7-14 March 1993, the proportion of different land uses were estimated to be as follows:

20 percent -	areas under crops in the past season.
30 percent -	recent fallow (with coppice regrowth of 1-2 m, and probably out of use for the past 2-3 years).
30 percent -	older fallow (bush regrowth over 2 m tall, and probably not cultivated in the past 3 years or more).
20 percent -	areas not cultivated in recent times, but grazed and with some woodcutting.

Vegetable gardens were present in the vicinity of habitations where streams and other damp ground were available in open grassy areas. These gardens would be a prime target for fertilizers and pesticides, and their occupants expressed a desire to use them if they could be obtained locally. The presence of these gardens in the immediate vicinity of drainage systems would enable any undergraded chemicals present in storm runoff to contaminate water supplies and rivers.

The rich alluvial soils along the Mayo Kebbi River near Léré and the shoreline around Lakes Léré and Tréné were among the most intensively used along the entire route, and most fields contained late crops of sorghum or vegetables. Many herds of cattle grazed between the fields and gardens or were brought daily from grazing areas in the drier surrounding bush to drink from the lakes. This zone of intensive land use is likewise a potential target for fertilizers and pesticides, which could endanger the aquatic life of the lakes and their isolated inland population of manatees.

The cultivated areas of southern Chad offer little habitat for most of the original mammals, birdlife, and insects originally found in the region. Few replacement species

appear to have taken up the niches created by the cropping, although seeds of some of the weeds and grasses might provide hitherto unavailable sustenance to small seed-eating birds.

Many flocks of Redbilled Quelea (*Quelea quelea*) were noted south of Bongor around Djouman. The strip-cropping of taro on the Logone floodplain is creating habitat attractive to them, and is thus posing a threat to the rice in the area. The annual grass *Panicum laetum* (kreb) that comes in to replace the climax *Andropogon* spp. has round seeds much favored by Queleas, which otherwise would not be found on these floodplains. *Andropogon* spp. does not produce seed suited to these birds.

As the human population increases, the lengthy period needed for the restoration of soil fertility by bush fallow is becoming less attainable. Around centers like Moundou, villagers are now cultivating continuously and may be diverting some fertilizer destined for their cotton to their garden crops. As the nutrients of these soils become more depleted, there will be a greater incentive to apply agricultural chemicals, with consequent environmental dangers. This process will be accelerated as animal plowing spreads, as that will require more removal of the original stumps and roots with reduced seasonal leafdrop from previous coppice.

The maintenance of soil fertility, structure, organic matter, and water-holding capacity can probably best and most economically be ensured if leguminous green-manure crops such as velvet-bean (*Mucuna* spp.) or sunn-hemp (*Crotalaria juncaea*) are introduced for plowing under in an annual rotation. This system was successfully used for many years by commercial maize farmers in Zimbabwe prior to the advent of fertilizers. Alley-cropping with leguminous trees (especially *Acacia albida*, or possibly *Parkia biglobosa*), would be another viable alternative in much of the south of Chad, and would assist in maintaining some of the avifauna and insects.

Much of the stover is currently cut and carted away for livestock feed, but the resultant manure is not returned to the land, as is done by peasant farmers in Zimbabwe. In some areas though, local or transhumant livestock graze on the fields after the crops are harvested. Drought and range degradation in the northern Sahel grazing areas are now forcing transhumant herders to compete for rangeland and arable land with the sedentary villagers of southern Chad, and there is virtually a state of war in the Sarh and Moundou Prefectures between these people.

Despite the numerous large trees left in the fields suitable as nesting sites for birds of prey, very few raptors were seen. Apart from the ubiquitous Black Kites (*Milvus migrans*), the most common were resident Grasshopper Buzzards (*Butastur rufipennis*), Dark Chanting Goshawk (*Melierax metabates*) and migrant Pallid Harriers (*Circus macrourus*) from Europe. The only eagles seen were one Martial Eagle (*Polemaetus bellicosus*) near Kyabé, one Brown Snake Eagle (*Circaetus cinereus*) in Manda Park, and one Bateleur Eagle (*Terathopius ecaudatus*) north of Guelengdeng.

112

B3b. Arable Lands in the Sahelian Savannah Area

As noted under B1b., agricultural production in this area is extensive on the sands, which are well suited to millet production. Groundnuts and cowpeas are also grown on these soils. In the broad silty beds of some of the wadis near Abéché, patches of *Acacia nilotica* have been cleared to grow tomatoes on residual moisture during autumn and winter. The soil moisture content is augmented in some cases by the erection of stone and earth embankments. The dryland crops are grown without the use of any purchased inputs. There is little likelihood of such inputs being economic in this semi-arid climatic zone because of their prohibitive cost so far from railhead and markets. Minimal quantities of pesticides and fungicides might ultimately be used on the tomatoes if they were locally available. The ATPRP project is not expected to have any impact in this area other than improved marketing following on an expansion of the vehicle fleet. The roads are frequently impassable during the rains because of flooded watercourses in the Guéra and stretches of clay soils.

B4. Wetlands

B4a. Rivers

In Chad, the principal permanent rivers and their tributaries arise in the south, with much of the flow deriving from the Central African Republic (the Chari, and the Logone), or from the Salamat flood-plains (the Bahr Salamat, the Bahr Keita, and the Bahr Aouk). The Chari and the Logone are 1200 and 1000 km long, respectively. All of these rivers drain into Lake Chad. The Mayo Kebbi arises near Pala and flows into Cameroon where it joins the Benoué River. Within Chad, these rivers have extremely flat gradients (except the Mayo Kebbi, where the Gauthiot Falls interrupt the otherwise level bed), and possess extensive and important floodplains.

Other rivers in Chad are seasonal, the extent and duration of their flow depending on the amount of rain each year. Many are subject to flash floods that last from a few hours to a few days, frequently leaving pools. The most important of these seasonal rivers is the Wadi Azoum, which arises in Sudan, draining the area between Jebel Mara (the 3000 m high extinct volcano), and the Chad border. This broad river spills onto the Salamat floodplain and into Lake Iro before eventually reaching the Chari River. Another is the Wadi Batha, which drains the Ouaddaï prefecture around Abéché and feeds Lake Fitri. A third important seasonal river is the Wadi Howar, which arises in the Ennedi Massif and flows east into Sudan, where it supplies a valuable resource for the wildlife of the semi-desert before sinking into the sands.

The permanent rivers and Lake Chad are the source of a considerable fishing industry. Fish are smoked or dried and sold domestically and in adjacent countries. Much research on the fish of Chad was undertaken in the past by the French, mainly through ORSTOM.

The very flat gradients of the rivers in the Chad Basin give rise to extensive sand banks, which attract many migrant waders during the Eurasian winter, as well as local Black Crowned Cranes (*Balearica pavonina*), Marabou Storks (*Leptoptilus crumeniferus*), Herons, Egrets, and Plovers. The vertical sandy banks are well-suited for nesting colonies of Bee-eaters such as the Carmine (*Merops nubicus*) and the Red-throated (*Merops bulockii*), as well as Kingfishers, but both of the former are inexplicably rare, and even the Pied Kingfisher (*Ceryle rudis*) is only seen infrequently.

B4b. Marshlands and Floodplains

The exceptionally flat terrain that characterizes most of Chad derives from the sediments and deltas deposited in the ancient paleo-Lake Chad, an enormous freshwater lake dating back to Tertiary times. The rivers fed from higher areas around the periphery of the bed of this former lake now meander across this vast plain, and during the summer rainy season, they regularly overtop their banks onto adjacent grassy floodplains. In addition, in Salamat and elsewhere, rainstorms cause temporary floods, often for extended periods, as the clay or silt soils prevent rapid infiltration of water.

The riparian floodplains are extremely important as nursery sites for fish that move upriver from lakes to spawn; therefore damage by arable cultivation or grazing affects the fish stocks. Any ATPRP influence on this process would be negative. These flooded areas are likewise a very important resource for water-birds.

It is important to note that the breeding grounds for the African Migratory Locust (*Locusta migratoria*) and the Sudan Plague Locust (*Ailopus simulatrix*) are the black cracking clay soils (vertisols) around lakes and floodplains. These are therefore likely to be subject to pesticide control campaigns when outbreaks occur. The pesticides selected for these campaigns must be selected with the greatest caution and used away from open water so that they do not contaminate any rivers that flow into Lakes Chad, Fitri, Léré, or any other body of water.

B5. Lakes

B5a. Lake Chad

Lake Chad sustains (though not on its former scale) a very substantial fish population and fishing industry, and immense flocks of Palearctic migrant waders and other wetland birds. In this century the extent of the lake has fluctuated considerably due to drought and wet cycles. It has ranged from a surface area of almost 26,000 km^2 in June 1962 (Kindler et al. 1989) to 1,653 km^2 in April 1985 (Kusnir 1993). At its lowest levels, the two basins have been physically separated by a dry ridge (the Grande Barrière). The present lake is only a minuscule remnant of the paleo-Lake Chad, which first came into existence by tectonic subsidence 35 million years ago. During a very wet pluvial period commencing about 50,000 years ago, the lake level was at 400 m with a surface area of around 800,000 km^2. It covered almost the entire country, stretching from near Kano in Nigeria to Faya Largeau and down to Sarh (Pias 1970). As recently as 6,000 years ago it was still 300,000

km^2 in extent, and 20 m deep where N'Djaména is now located (Kusnir 1993, and Pias 1970). The present surface of Lake Chad is about 282 m above sea level at "normal" levels, when the lake has a maximum depth of only a few meters. The very flat terrain in which it is situated means that very slight changes in lake levels create vast changes in the area flooded or the amount of lake bed exposed.

There are three main types of habitat within the lake: the scatter of small islands (tops of submerged dunes) in the north-eastern section; the islands (some floating, some rooted) of papyrus (*Cyperus papyrus*) and reeds (*Phragmites*); and the areas of open water (Kindler et al., 1989). There are also extensive beds of bulrushes (*Typha australis*) and papyrus and other sedges around the shores.

The vast populations of migrant birds at Lake Chad are sustained in part by midges (Diptera: Chironimidae), of which 93 species have been identified (Dejoux 1968). One minute green midge (*Tanytarsus spadiceonotatus*) was so abundant that at times they resembled clouds of green smoke, and settled so thickly on grasses and sedges that birds gathered them by running their open beaks up the stems.

The aquatic larval stages of these midges, together with other phytoplankton and zooplankton, are the base of the food chain of the abundant fish population. There are 120 species of fish in the lake and its associated backwaters; these occur most abundantly among the islands and vegetated areas and are essentially riverine rather than lacustrine types. Many species are replenished by juveniles migrating down-river from the flood-plains ("yaeres") where they were spawned. During dry years, the fish in the lake are unable to migrate between the two pools. Lately, there has been serious overfishing and smaller mesh nets. Between 1962 and 1970, fishing increased 30-fold, and 120,000 tons were caught annually in the southeastern part of the lake prior to the drought years. However, *Alestes baremoze*, the most important of the commercial fish species, had been especially severely affected since 1971 (Kindler et al. 1989). There is currently no enforced regulation of the fishing industry on the lake. The fish are dried or smoked, the latter method adding to the demand for fuelwood in the area.

In the past, the lake supported hippopotami (*Hippopatamus amphibius*), swamp-dwelling sitatunga (*Tragelaphus spekei*), two species of otter (the Cape Clawless Otter, *Aonyx capensis*, and the Spotted-necked Otter, *Lutra maculicollis*), elephants (*Loxodonta africana*), and crocodiles. All of these have been severely impacted by human intrusion (herders, farmers, and fishermen), poaching, and drought, and all are thought to be endangered, but there does not appear to be any reliable current information.

In the dry season, the exposed areas of the lake bed attract transhumant herders from the north with large numbers of animals, disturbing the larger wildlife and competing for grazing land. Recessional cropping of sorghum (berberé) on residual moisture is an important activity that yields an estimated 150,000 tons of grain, principally for sale in Maiduguri (Kindler et al. 1989).

The water table of the lake augments the rainfall and helps flood the interdunal depressions on the north side of the lake, enabling maize and wheat to be grown, often with the aid of polders to dam these waters. An important source of food protein is the blue-green algae (*Spirulina* spp.) that proliferates in stretches of carbonated water. It is harvested for making proteinaceous sauces; commercial expansion for export to the high-value health-food market could prove very profitable.

Regrettably, despite the exceptional international importance of this unique ecosystem, apparently no formal protection exists for any segment of it. The nearest reserve is the Bas Chari Fauna Reserve (also known as Douggia F.R.), apparently of uncertain status, along the eastern edge of the Chari River between N'Djaména and Douggia. This area is savannah woodland in the Sudano-Sahelian bioclimatic zone and does not encompass any segment of the lake. The reserve formerly contained a representative selection of savannah wildlife, including elephant, giraffe, lion, buffalo, etc., but the spread of automatic weapons, and the collapse of civil authority during the unrest of the past two decades, has eliminated all large mammals, and grazing and tree cutting have apparently been widespread. The Bas Chari F.R. does not embrace any of the aquatic habitats, nor do there appear to be any reserves encompassing such habitats in the other states that border on Lake Chad (the Lake Chad Game Sanctuary in Nigeria also does not abut the Lake). Possibly because of its neglected status, the Bas Chari F.R. is not even listed in the Directory of Afrotropical Protected Areas (IUCN, 1987).

The four member states of the Lake Chad Basin Commission (LCBC) adopted the Agreement on Common Regulation of Flora and Fauna at their 24th session in 1977, which could have ensured a joint approach to the conservation of Lake Chad, but it has not been applied, especially in recent years.

B5b. Lake Fitri

Lake Fitri lacks the variety of fish found in Lake Chad, possibly because it has dried up on at least two occasions during the recent drought years of 1973 and 1984. The only fish that would normally be able to survive such desiccation by aestivating in the dry mud are the African Catfish (*Clarias gariepensis*) and the African Lungfish (*Protopterus* spp.), which are probably the mainstay of the current fishing industry.

Lake Fitri is fed by seasonal flow from the Batha River, and various other ephemeral wadis (July to October). In normal years it has an extent of about 800 km^2, and a water depth of between 1.5 and 2 m. The lake is surrounded by extensive clay soils that remain temporarily flooded during the summer rainy period and support extensive stands of *Acacia seyal*. These clay soils make the lake almost unapproachable during the wet season, and even in the dry season, access is very difficult due to loose sandy tracks outside the clay area.

The White Pelicans (*Pelecanus onocrotalus*) that fish in Lake Fitri use the squared-off top of the unscalable 300 m granite peak Ab Touyour near Bitkine as a nesting site; this involves a flight of approximately 120 km in each direction. The summit of this pinnacle

would appear to be able to accommodate about 200-400 nests. As recently as 1990, a small remnant herd of elephant was reputed to still be present near the lake (Tchad 1991b).

The area of the lake and adjacent wetlands appears to be about 875 km^2 (Kindler et al. 1989), but the area of the proposed biosphere was listed as 1,950 km^2. Whether this new status will contribute to the preservation of the environment and associated wildlife is questionable in view of mounting human pressures and the lack of GOC funds for staff and supervision. There had been plans for development at Lake Fitri, to be financed by the Islamic Bank for Development, in association with CEDRAT and BIEP (Kindler et al. 1989); whether these will proceed is unknown.

B5c. Lakes Léré and Tréné

Lakes Léré and Tréné are located on the Mayo-Kebbi River in the southwest corner of Chad. Lake Léré is much larger than Lake Tréné, and appears to cover an area of about 10x3 km. Because of the unique reversible drainage in the headwater swamps, which can cause water to flow towards either the Logone or the Mayo-Kebbi, the fish population of these lakes is a combination of Chad basin and Niger River species (Kindler et al. 1989). These two lakes are separated from a series of further small lakes upriver (Lakes Tikem, Fianga, Kablia) by the Chutes Gauthiot. This is a set of three waterfalls created by a barrier of granite, which had been under consideration for a hydroelectric project. This would have resulted in a disastrous diversion of water from the Logone and its floodplains had it been adopted, but fortunately this scheme has apparently been abandoned (Kindler et al., 1989).

B5d. Lake Iro

Of all the lakes in southern Chad, Lake Iro is the most isolated and pristine. It has an important fishery that supports a local village of 30 families (Anita Mackey, personal communication). The lake has been proposed for protected status as a biosphere reserve. ATPRP is not expected to affect the lake or the extensive natural habitats nearby. However, because of its uniqueness its condition should not be compromised.

B5e. Other Lakes

In the B.E.T., 220 km northeast of Faya Largeau, is the unique Lake Yoa at Ounianga Kébir and a set of five finger lakes nearby at Ounianga Sérir. These are fed by underground aquifers, but are not currently accessible. They could be of great interest to tourists visiting the Tibesti/Ennedi region in the future, because of their dramatic scenery.

C. Description of Wildlife Resources

Research into the wildlife resources of Chad has been directed mainly at two geographical areas: Lake Chad and the massifs and desert of Tibesti/Ennedi. Elsewhere, research has been very patchy and infrequent; knowledge of the fauna and flora of Chad is sparse and hard to locate. Because of Chad's variety of habitats, there is a corresponding variety of fauna and flora; in fact, in the past the country was renowned for this.

C1. Categories of Wildlife Resources in Chad

C1a. Mammals

Regrettably, virtually all the larger mammals have been killed during the past two decades as a result of the automatic weapons and four-wheel-drive vehicles. Even the national parks and faunal reserves were severely or entirely depleted, especially the more accessible ones such as Manda, Mandelia, and Bas Chari. The opening up of boreholes, which enables formerly nomadic people and their herds to remain continuously in areas that previously were only grazed for relatively short periods, combined with natural population increase and the effects of drought, have also had a marked impact on the number of wild game animals.

Chad formerly possessed an exceptionally wide range of large, rare, desert mammal species such as the Scimitar-horned Oryx (*Oryx dammah*), which was so common in the northern deserts that it was not placed on the list of protected animals, the Addax (*Addax nasomaculatus*), the Black Rhinoceros (*Rhinoceros bicornis*), and various gazelles including the Dama (*Gazella dama*) and the Slender-horned or Rhim (*Gazella leptoceros*). These five species are now either extinct or very nearly so in Chad. The accompanying list of rare and endangered species mentions many others which are now either nearly extinct in Chad, or are under severe threat.

Very few of the 60-65 large mammals of Chad survive outside of the Zakouma National Park, where 47 species of mammals have been listed. In a recent visit to the Ouadi Rime-Ouadi Achim Faunal Reserve, only six Dama Gazelle were seen, together with a few Dorcas Gazelle (*Gazella dorcas*) and a few ostrich (J. Pfeffer, personal communication, February 1993). The antelope specialist group studied the Chad Basin in 1988, but their report has not been available. Le Berre (1990) records 37 species of mammals from the arid northern third of Chad. LaVoie (1989) discussed the rodent pests of the Sahel, including Chad. Vielliard (1974) recorded 21 species of bats in Chad. Small mammals are normally only impacted by human expansion and activity to the extent that their habitats and food sources are destroyed—some, such as certain rodent pests, benefit by human intervention.

C1b. Birds

As birds are often more habitat-specific than mammals, it can be expected that the variety of habitats in Chad will give rise to a greater wealth of bird species than of mammals. No overall account of the birds of Chad appears to have been published, but a comprehensive survey of the species of birds in Chad was undertaken by Salvan, who visited all the prefectures in 1967-69, and recorded a total of 488 species (Salvan 1967-68). Other sources, such as Kindler et al. (1989) give a figure of "approximately 500 bird species, excluding rarities" for the Chad Basin. In Zakouma National Park, close to 300 species of birds have been observed. A team of three British ornithologists recorded 230 species of birds (86 passerines and 144 monpasserines of which perhaps 76 species were palearctic migrants) on and adjacent to Lake Chad in a 6 week period during March/April 1967 (Ash, et al., 1967). Lakes Chad and Fitri support vast numbers of palearctic migrants, especially

waders and ducks. Ash et al. recorded flights of 4000 per minute for Yellow Wagtails (*Motacilla flava*), 100,000-175,000 per hour for Sand Martins (*Riparia riparia*), and large flights of Whitethroats (*Sylvia communis*) on passage to and from Africa and Europe. One bird which is currently only known from Lake Chad is the River Prinia (*Prinia fluviatilis*), a small species in the Grass Warbler family which was only recently discovered and described. The rare Marbled Teal (*Marmaronetta angustirostris*), which has a very restricted distribution in North Africa and Turkey, is among the various unusual species that have been recorded there.

The raptors of Zakouma and Manda National Parks were studied by Thiollay in April 1973 (Thiollay 1975). He listed a total of 49 diurnal birds of prey, with a distribution rate averaging 2-5/km; of these, 20 species of eagles and vultures comprised 70 percent of the total individuals, and had a frequency of 1-3/km. These figures are far in excess of those found outside the parks, and are an important reflection on the disappearance of animals and habitat in the occupied savannah areas. The avifauna of the Ouadi Rimé-Ouadi Achim Faunal Reserve was studied by Newby (1979) between 1971 and 1978. In this 77,950 km^2 area, which ranges from north-Sahelian wooded steppe through sub-desert steppe to run-off desert, he noted 267 species of birds, an indication of the very rich avifauna in Chad prior to environmental degradation.

Some birds have benefitted from human expansion in Chad and are sufficiently common to be a major threat to grain crops, such as the Redbilled Quelea, Golden Sparrows (*Passer luteus*), Village Weavers (*Ploceus cucullatus*), and Fire-crowned Bishops (*Euplectes hordeaceus*). Queleas breed in dense colonies in thickets of *Acacia seyal* or other species of acacia in the Lake Chad basin, and are periodically poisoned by the GOC. The *Collins Field Guide to the Birds of West Africa* (Serle et al. 1977) is the best reference book to the birds that occur in Chad, but not all the species recorded in Chad are described or illustrated in it.

C1c. Fish

The distribution of fish species in Chad is determined by the catchments which segregate them. These comprise:

- Lake Chad and its feeder rivers (the Chari, the Logone, and their tributaries).
- Lake Fitri and its feeder rivers.
- The streams, wadis, and gueltas (rocky piedmont pools) of the Tibesti/Ennedi massifs.
- The Mayo Kebbi River, with its tributaries and lakes that drain into the Benue and the Niger River.

As in the case of the mammals and birds, Chad was blessed with an exceptional abundance of fish, but over-exploitation, drought, and possibly environmental degradation have drastically reduced the catches of what had been a major industry. The fish of the Lake Chad catchment and the adjacent Mayo-Kebbi catchment have been studied extensively (Blache & Miton 1963, Blache 1964). The fish of the Borkou Basin (Tibesti/Ennedi drainages) are summarized in *Faune du Sahara* (Le Berre 1989), which lists 11 species of

fish, the majority endemics. The Lake Chad basin has 130 species of fish. The most important have been the Characin (*Alestes baremoze*) and the Nile Perch (*Lates niloticus*); the latter used to be large, but now seldom exceeds 5-8 kg, and the former has drastically decreased in numbers. Nelson (1976) grouped the species of fish in Chad into 12 families, suborders, and subclasses.

The elimination of crocodiles and hippopotami, the degradation of floodplains for spawning (by conversion to agriculture and grazing), and the overexploitation and harvesting of undersized fish with reduced mesh nets is seriously impacting fish stocks. A principal prey of crocodiles are catfish; when crocodiles are hunted out, the catfish proliferate and consume the eggs and fry of tilapia and other desirable Cichlid fish. Hippopotami fertilize the water with their dung and also stir up sediments, and are therefore instrumental in maintaining fish stocks.

C1d. Reptiles and Amphibians

There is no overall review of this component of the fauna of Chad, and knowledge of the local species is very incomplete as little systematic work appears to have been done in this sector. Only two publications list some of the Chadian species (Le Berre 1989 and Wake & Kluge 1961)—both of these are largely focused on species occurring in the northeast of Chad. Ernst & Barbour (1989) report six species of turtles and tortoises in Chad, of which the large Desert Tortoise (*Geochelone sulcata*) is of special interest. Although the IUCN Red Data Book (Groombridge, 1982) lists the African Slender-snouted Crocodile (*Crocodylus cataphractus*) as occurring in Chad, there does not appear to be corroboration of this in other sources. The Nile Crocodile and Water Monitor Lizard (*Varanus niloticus*) have been extensively hunted for the skin trade and both are now seldom encountered. The African toad (*Bufo regularis*) is very common in N'Djaména, as well as other towns, where they assist gardeners by consuming large quantities of crickets and grasshoppers. Often seen in gardens in summer is the Savannah Chameleon *(chameleon gracilis)*, also a useful creature. The common Orange-headed Agama (*Agama agama*) on the other hand, is a pest in gardens, as they eat flowers and seedlings to supplement their diet of ants. The snake population of Chad has not been well documented. Eleven species of snakes have been recorded in Zakouma National Park, and Matheson (1986) records seven vipers from Chad. African Rock Pythons (*Python sebae*) have been hunted for their skins, but are also killed because Africans tend to fear all snakes, making no distinction between poisonous and harmless species, or even chameleons.

C1e. Invertebrates

The summer rains produce outbreaks of enormous numbers of insects of all types, including agricultural pests such as grasshoppers, locusts, and crickets. The floodplains of the Chari Basin are a breeding ground for the African Migratory, Sudan Plague, Desert (*Schistocerca gregaria*) and Tree (*Anacridium melanorhodon*) locusts. Tsetse Flies (*Glossina* spp.) formerly extended along much of the Chari River and elsewhere in southern Chad, but their range appears to have contracted considerably as a result of the elimination of game animals and deforestation. The dense numbers of chironomid midges that occur at Lake

Chad are important for fish and for migrant birds, who require fat reserves to fuel their 1500 km non-stop Sahara crossing. Honey bees (*Apis mellifera*) occur sparingly through the savannah woodlands; strangely, no indigenous bee-keeping appears to be practiced in Chad, and no traditional bark hives were seen on either of the two tours undertaken by the team. Apart from specialist studies on a few families, there has been very little entomological work in Chad, and there does not appear to be any publication covering butterflies. No invertebrates are listed as endangered in Chad (Wells et al. 1989).

C1f. Plants

According to the IUCN publication *Plants in Danger—What do we Know?* (IUCN 1986), approximately 1600 species of vascular plants are known in Chad, of which 1516 occur south of about latitude 16° N—a somewhat low figure for a country of this size and range of climates. The Tibesti Mountains are estimated to have about 450 species, but the number of endemics is not recorded. The main floral regions in Chad are Saharan in the north, Sahelian in the central third, and Sudanian in the south, and are largely a reflection of increasing rainfall. The Tibesti Mountains have a mix of Mediterranean, Saharan, Sahelian, and Afromontane elements (IUCN 1986).

Botanical exploration has been reasonably comprehensive in Chad, and the results are covered in various checklists and maps, particularly by Lebrun et al. (1972, 1976, 1977), and Pias (1970). The latter work includes a very detailed vegetation map of the southern half of Chad below 16° N. However, some of the savannah vegetation communities depicted on it appear to have altered since it was compiled, probably because of the decrease in rainfall in the past few decades and human-induced degradation.

The alternation between summer rains and a long dry season in Chad has resulted in a vegetation that is mainly deciduous, or annual in the north. The northern trees and shrubs are mostly thorny, with *Acacia* spp. and *Balanites aegyptiaca* predominating, but these become phased out and the trees become taller and more closely spaced in the wetter savannah woodlands of the Sudanian and Guinean zones.

C2. Use of Wildlife Resources for Food, Sport, and Profit

The larger game mammals of Chad formerly attracted a regular stream of overseas hunters, always a useful source of income to a country in need of foreign exchange. These game animals were also a traditional source of meat for villagers, especially in times of famine, and their skins have been useful in a variety of ways.

The trees of Chad provide the fuel needed for cooking by the urban and rural populations, either as firewood or after conversion into charcoal. Various trees, such as most of the acacias, are especially in demand because of their high calorific value. Other trees are valued for their fruit, and are seldom felled, including *Balanites aegyptiaca*, *Sclerocarya birea*, *Parkia biglobosa*, *Ficus* spp., *Tamarindicus indica*, and *Prosopis africana*. Some are protected or encouraged because of the oil they provide from their seeds (*Khaya senegalensis*, *Butyrospermum parkii*). The Baobab (*Adansonia digitata*) has a

number of uses: the fruit has an exceptionally high heat-stable Vitamin C content, the leaves are used as a spinach, and the bark yields fiber. Other trees and bushes are also used for fiber. Leaves of palms (*Hyphaene thebaica* or *Borassus aethiopum*) are used for basket weaving and matting, palm wine can be made from the sap, and construction poles are made from the trunks. Many trees, shrubs and herbs are the source of medications, usually from bark or roots. Gum Arabic is derived from two species of acacia in the Sahel zone: *Acacia senegalensis*, which grows on the better drained sands, and *A. seyal*, which grows on seasonally inundated clays. The former tree provides the better quality gum, but is now relatively scarce as much of these sand areas has been converted to millet lands, and the practice of encouraging the regeneration of *A. senegalensis* by reseeding appears to be lapsing. The uses to which the trees and shrubs are put in Chad is covered in a number of books illustrated with color photos (Fortin et al. 1990, Pousset, 1989 and 1992).

Chad has some unique wildlife areas, animals, birds, scenery, geology, rock engravings and paintings that could form an interesting basis for tourism if the climate stabilizes and minimal infrastructure is developed. In the interim, it is essential that these resources be maintained at acceptable levels and not permanently lost.

C3. Wildlife Management Programs in Chad

The breakdown in law and order in Chad during the last two decades, coupled with grazing crises arising from two sets of droughts, has caused widespread disruption in land occupancy patterns. It has enabled militia and others to supplement their meat using automatic weapons now widespread. National parks and faunal reserves became easy target areas for hunting, elephant and rhino poaching, and grazing by transhumant herds driven out of their normal areas by war and drought. Existing regulations were unenforceable and widely disregarded. The elephant population plummeted from 16,000 to 2,300, and the Black Rhinoceros, the Addax, and the Scimitar-horned Oryx may have been exterminated in Chad.

Because of world-wide concern for elephants, and the need to establish a permanent sanctuary for those remaining in Chad, the EC/FED commissioned a survey and conservation plan (Tchad 1991), and has provided funding for two expatriate specialists, a team of game guards, and logistical material for the rehabilitation of Zakouma National Park. An army detachment was sent to Zakouma about three years ago at the request of the FED delegate, and was apparently very successful at curbing the prevalent poaching.

The directorate of parks and faunal reserves has virtually no operating funds or vehicles to enforce wildlife legislation in the existing parks and reserves. For the foreseeable future, the directorate will have to rely on donor assistance to re-equip and operate in the field. The existing wildlife legislation requires overhauling, as it is inadequate and antiquated. The GOC and the IUCN recently signed an accord to confer international biosphere status on Lake Fitri, and it is possible that similar status may be conferred on the Binder-Léré Fauna Reserve in order to provide better protection to this important ecosystem and the manatee population in Lake Léré. However, until there are more funds for wildlife conservation and management, better (preferably all-weather) access roads, and education of

the rural population on the need for wildlife and environmental conservation, little improvement is likely. All the good intentions of the staff of the directorate in N'Djaména are of no avail unless these can be translated into action in the field.

C4. Special Wildlife Concerns

C4a. Rare, Threatened, and Endangered Species

According to King (1981), the Eurasian Peregrine Falcon is the only endangered bird in Chad. However, as shown in the accompanying list of rare and endangered species (Appendix E-1), a number of mammals and birds are under severe threat, and some may indeed already be extinct in this country. Their continued existence will depend on the continued availability of sufficient suitable habitat and on the awareness of rural and urban populations of the need to conserve both habitats and the species they support. Better policing of the current reserves will in itself not be sufficient to ensure that the wildlife of Chad continues to exist.

C4b. International Conventions

Chad is a signatory to the Convention Concerning Protection of the World's Cultural and Natural Heritage and to the African Convention of Nature and Natural Resources, but the country has not ratified the latter (Robinson, 1989). The government also has not ratified the following agreements, as described by Goodman and Meininger (1989):

- African Convention for the Conservation and Management of Wildlife and its Habitats.
- African Convention of Nature and Natural Resources.
- Convention on Wetlands of International Importance Especially as Waterfowl Habitat (RAMSAR Convention).
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES III).
- Convention for the Conservation of Migratory Species of Wild Animals (Bonn Convention: Boere, 1991).

C4c. Palearctic Migrants

Palearctic migratory birds comprise two broad categories, those associated with wetlands and those utilizing savannah or woodlands. As shown by surveys undertaken by the B.O.U. team (Ash 1987), vast numbers of Palearctic migrants use Chad's wetlands for some or all of their winter sojourn in Africa. Human population pressures at Lake Chad, resulting in part from drought, have forced people from elsewhere to use the exposed lake bed, its waters, and the adjacent areas more heavily than at any time in the past. The 30-fold increase in fish catches (Kindler et al. 1989) is an alarming indication of these pressures.

The recent accord conferring international biosphere status on Lake Fitri is a useful step in ensuring its continued undisturbed existence. The inaccessibility of this lake,

especially during the rains, coupled with the restricted range of fish species, are probably the main factors which have hitherto limited human settlement or use of the lake and its surrounds. The numerous migrant and resident water birds that use it will now have a more secure future.

The other wetlands of Chad (rivers and floodplains) extend the area available for use by migrants and other birds that prefer riverine situations, but they are not normally as suitable as the lacustrine ecosystems for many of the Palearctic migrant species. It is essential that some control of the use of Lake Chad be instituted to protect avian populations now dependent on this ecosystem. For maximum effectiveness, such controls need to be coordinated with the neighboring states (Nigeria, Cameroon, and Niger) that share the lake. The LCBC would appear to be the best vehicle for initiating and administering this.

Palearctic migrants also utilize Chad's savannah and woodland areas during migration or their winter sojourn in Africa. The Warbler family (*Sylviidae*) are the most numerous, especially the Whitethroat (*Sylvia communis*), the Willow-warbler (*Phylloscopus trochilus*) Swallows, Shrikes, and various raptors (eagles, buzzards, harriers, kestrels, and kites), are also common seasonal visitors. For all of these, habitat preservation is vital for their continued existence.

C4d. Raptors

As shown by the survey of the raptors of Zakouma National Park (Thiollay 1975) an exceptionally high number of species and total of raptors can be sustained in this undisturbed mosaic of woodland, grassy floodplains, and aqautic habitats. Thiollay listed a total of 49 species with a distribution rate of 2-5 per km. The tour undertaken by this team through adjacent populated areas, even though not specifically designed for raptor surveys, illustrated the reduction in raptor numbers that occurs when habitats are degraded and wild animals killed off. Not only are many raptors deprived of their food sources, they also frequently lose their breeding sites through the conversion of pristine woodlands to cultivation. A few species benefit from this, such as the harriers, which require open ground for their aerial hunting, or kites and Hooded Vultures (*Neophron monachus*), which tend to be scavengers around villages. Hawks and eagles, however, tend to be especially persecuted by farmers and villagers, who suspect them of taking poultry or young lambs.

Potential tourists who might consider coming to Chad to bird-watch will most certainly wish to see as many birds of prey as possible, just as others are attracted to the big cats.

C4e. Unique Species and Habitats

Chad has (or had) a number of birds, animals, and habitats of special interest. Lakes Chad, Fitri, Léré, and Tréné have already been mentioned, the first two for their wealth of bird life, the second two for the manatees. Lake Yoa in the B.E.T. has also been mentioned for its dramatic scenery and exceptional tourist potential. The "Elephant Rock" at Hadjer el Hamis on the southern edge of Lake Chad, and its companion inselbergs, are very dramatic,

rising straight out of the flat plain (they are remnant plugs of rhyolite lava that cooled into columnar formations in volcanos that have long since eroded). They attract and support a host of cliff-dwelling birds, and could be a centerpiece for a faunal reserve.

The Ouadi Rimé-Ouadi Achim Fauna Reserve urgently needs protection to restore the vanished herds of Scimitar-horned Oryx, Addax, gazelles, ostrich, and bustards. These latter birds, if adequately conserved throughout the semi-desert areas, could be placed on a limited-hunting basis for oil-wealthy falconers from Arabia, but great care would be required to ensure that quotas were not abused.

The area around Baibokoum at the southern tip of Chad may contain flora and fauna that are found nowhere else in the country, due to the combination of higher elevations and rainfall. This should be investigated as a possible basis for a nature reserve.

D. Critical Habitats

Habitats that provide essential life requirements are a prerequisite to the maintenance of healthy, abundant wildlife populations. Although some areas that support wildlife elsewhere in Chad are in fair to good condition, most animal habitats in the project area have been severely degraded. Clearing for agriculture, firewood, and grazing has seriously reduced the carrying capacity of the land, especially in the southern provinces where human populations are the highest and land use the most intense (Tchad 1992). Drought across the Sahel has aggravated this situation in most countries (Warshall 1989).

A number of lakes and terrestrial sites must be protected to ensure their continued value to wildlife. These are designated here as critical habitats. Economic activities generated by ATPRP must not allow degradation in those areas. In the past, Chad had an extremely rich and varied flora and fauna; its natural resources equalled those of the most productive sites elsewhere in Africa. Chadians will be poorer both culturally and economically if their wild areas are completely degraded and their wild animals decimated or extirpated. Hecht (1993) has argued persuasively that the Chadian economy depends heavily on its natural resources. A healthy environment can enable sustainable production of food crops, livestock, trees and wildlife; likewise it enhances the lives and protects the cultural values of the human population.

Critical habitats are areas of forest, upland savannah, and marsh that provide the essential life requirements for both resident and migrant wildlife species. About 480 species and subspecies, and perhaps 5 billion individual birds from the palearctic region of Europe and Asia migrate regularly to tropical and southern Africa (Moreau 1972). Most winter north of the equator. Likewise, some 532 species and subspecies of African birds undertake seasonal migrations within the continent. Many of those afrotropical migrants breed in or move through the savannahs of Africa, including those in Chad. Interior marshes, shallow lakes, and river shores are feeding and resting areas for waders and other aquatic species, and may support thousands of birds at any one time.

The first large productive wetlands available to migrating birds crossing the Sahara desert are in the dry savannah and grass steppe type (see Map E-6 on the following page). The wetlands stand out in the otherwise dry steppe and include the inland delta of the Niger river, the Lake Chad basin and Lake Fitri, and the Sudd marshes of the Nile in southern Sudan. Lakes Chad and Fitri also support large numbers of resident waterfowl and waterbirds, as well as populations of several large mammals. The lakes are shallow (2-10 m) and have extensive feather-edges of water that support different kinds of submergent and emergent vegetation, plankton, other invertebrates and fishes on which waterfowl, shorebirds, and wading birds feed.

In the Sudanese and Guinean savannah belt across Africa, a diverse number of terrestrial migrants are spread throughout large areas. In addition to the migrants, there are many resident and indigenous species that depend on habitats in Chad for their life requirements. These include an impressive array of small birds, mammals, reptiles, amphibians, and fishes, as well as the larger, more obvious ostriches, raptors, antelopes, elephants, and crocodiles.

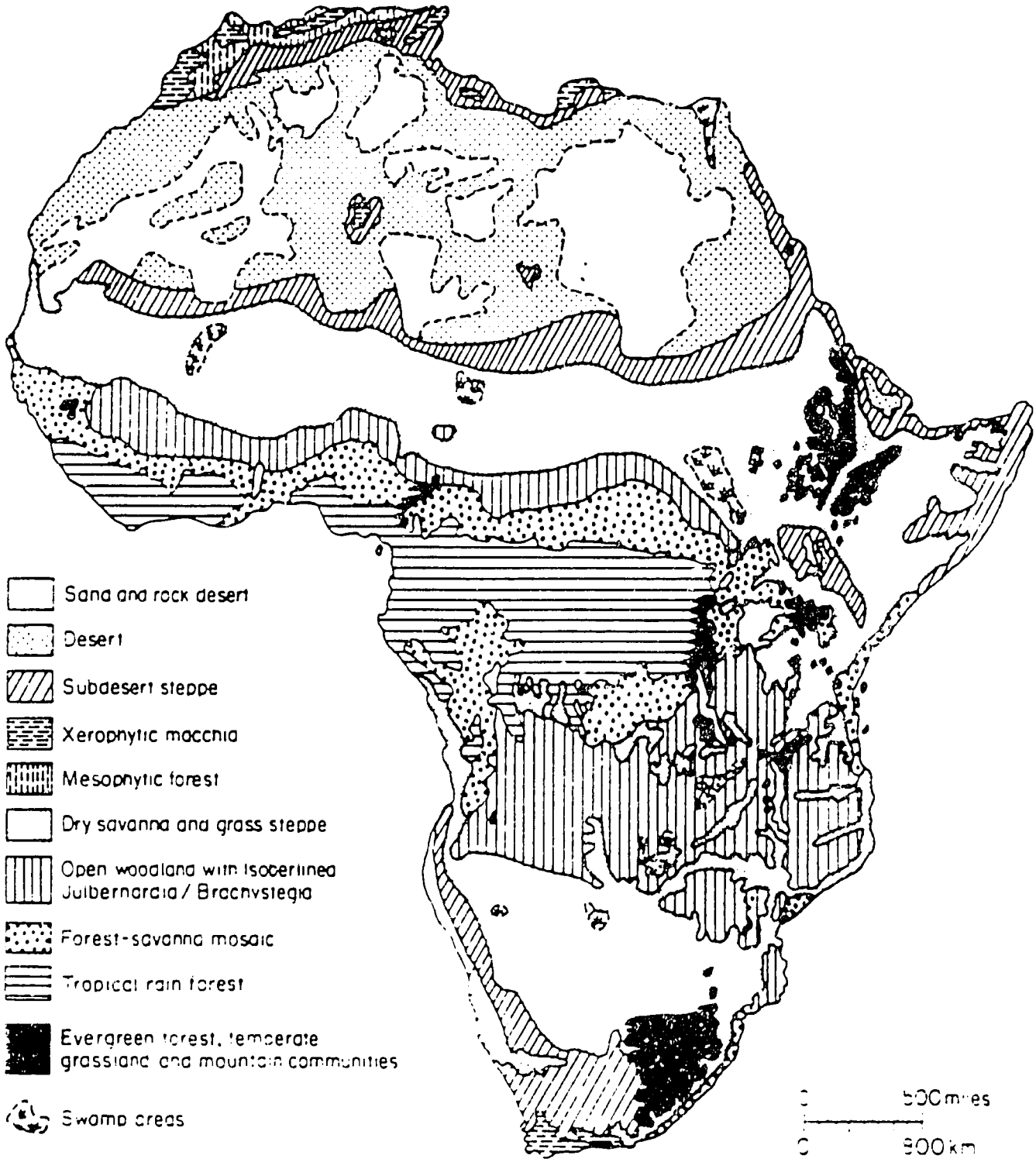
D1. Lake Chad

Lake Chad is the second largest lake in west Africa and is one of the most important wetlands on the continent. It and Lake Fitri provide essential resting and feeding habitat to both palearctic and afrotropical waterfowl. On Lake Chad, Ruffs (*Philomachus pugnax*) are often common and over 1 million have been seen on the lake at one time (Fanshawe and Gretton 1989). During an aerial survey in 1984 over 700,000 waterfowl were seen, which represented one-half of the West African population of waterfowl (Roux and Jarry 1984). Vielliard (1972) listed 17 species of ducks on the lake. Recoveries from a number of ducks banded in Europe have shown the importance of the lake to migrating waterfowl (Ash et al. 1967). The River Prinia occurs only in Chad, Niger, and northern Cameroon in the Lake Chad area. This rare species has been listed as threatened (Collar and Stewart 1988), but little is known of its range, abundance, or status. Another species listed as threatened worldwide is the Marbled Teal, which ranges from the Canary Islands to Southeast Asia. The teal is occasionally seen on Lake Chad (Fanshawe and Gretton 1989).

The Chari and Logone Rivers provide most of the water entering Lake Chad. Although the lake sits in a closed basin in a very arid zone, its salinity is low. No limestone is in the watershed and the tributaries carry a low ionic load. Biogeochemical sedimentation in the lake reduces salts by 45 percent, infiltration of lake water into deeper aquifers helps to leach salts from the lake, shell growth by mollusks helps regulate calcium ions, growth of macrophytes helps regulate potassium and silicates, and diatoms also help regulate silicates (the above was paraphrased from Kindler et al. 1989). Effects of increased siltation and agrochemical pollution could alter the current ionic stability of the lake.

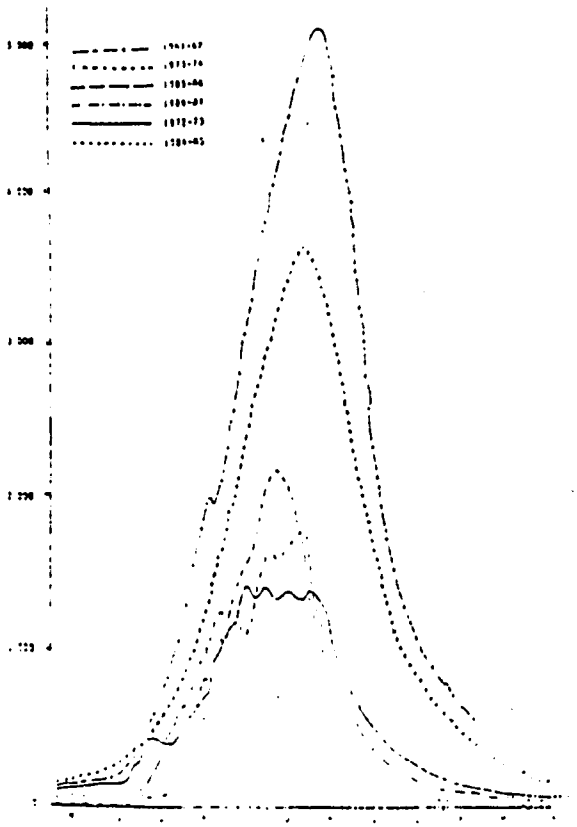
Lake Chad suffered considerably from drought conditions in the Sahel between 1975 and 1985. River flows decreased (see Figure E-7, page E-27), and upstream water use added to the shortage of flow into the lake (Ash and Shariand 1987). During the past century the surface area of the lake has varied from 3,000 to 25,000 km^2, depending on variations in

Map E-6: The Vegetative Zones of Africa Showing the Chad Basin and Other Wetlands of the Dry Savannah



Source: Moreau 1972

Figure E-7: Flows (m^3) of the Chari River at N'Djamena During Wet, Average and Dry Years



Source: Chad 1991

rainfall and surface and subsurface inflow. After 1985, the area of open water in the lake increased, but it has not attained its size of the recent past. A program to conserve the lake is needed, but it would be costly and would require cooperation between the four countries that share its shoreline (Fanshawe and Gretton 1989). A plan for the management and conservation of Lake Chad has been prepared by UNEP, Nairobi (Tolba 1992), but its proposals are not known as the plan was not available in Chad. The lake and its tributaries have supported some 130-160 species of fish, an excellent fishery, and about 20,000 professional fishermen (Tchad 1987, Kindler et al. 1989, and USAID 1991).

Apparently the most prized fish in the lake (*Alestis baremoze*) has now disappeared (Kindler et al. 1989); the reason was not given, but the implications could be serious to other species and the fishery they support. Some 21 species of lake fish migrate up the Chari-Logone river system to the Logomatia marshes to spawn. Fry return in drainages through the marshes to the El Beid river and then to the lake. This spawning area could be altered and degraded by sediment and agrochemical pollution of the rivers. Since the recent war there have not been any surveys of species, size classes, production, fishing effort, and catch or annual variations in these features (Kindler et al. 1989). Surveys are needed to update data obtained in earlier years (Blache et al. 1963 and 1964).

D2. Lake Fitri

Lake Fitri has been called a miniature Lake Chad. It, too, is a shallow lake and has completely dried up during recent drought years. The lake can double or triple in size during wet years (420 to 1300 km^2). At normal levels the lake's depth is only several meters and its waters are not highly saline (Kindler et al. 1989). The lake has a productive fishery that is important to the local economy. The lake is of critical importance to migratory waterfowl; 145,000 birds were counted during one survey. The Bureau International pour la Recherche sur les Oiseaux d'Eau, which operates in association with the Waterfowl Trust at Slimbridge, England, conducted waterfowl censuses in 1984, 1986, 1987, and 1988, but their results were not available in Chad. The GOC recently signed an agreement with IUCN establishing Lake Fitri as a biosphere reserve (Ymary, Director of Parks and Faunal Reserves, personal communication). Elephants still exist near the lake (Tchad 1991b).

D3. Lake Léré

Lake Léré and the much smaller Lake de Tréné are on the Mayo-Kebbi drainage near the town of Léré. The river flows through the lakes, and continues on into the Niger river system. The lakes and the town are within the Binder-Léré Faunal Reserve, which centers around the Chutes Gauthiot, where Roan Antelope, Bubale Hartebeest (*Alcelaphus bosephalos*), and other larger mammals still are present. The reserve has been given a high priority for rehabilitation when funds are obtained. There is considerable agriculture on the shores of the lakes and upstream along the river. Cereal grains are grown and there are many gardens, including some that are irrigated and treated with insecticides.

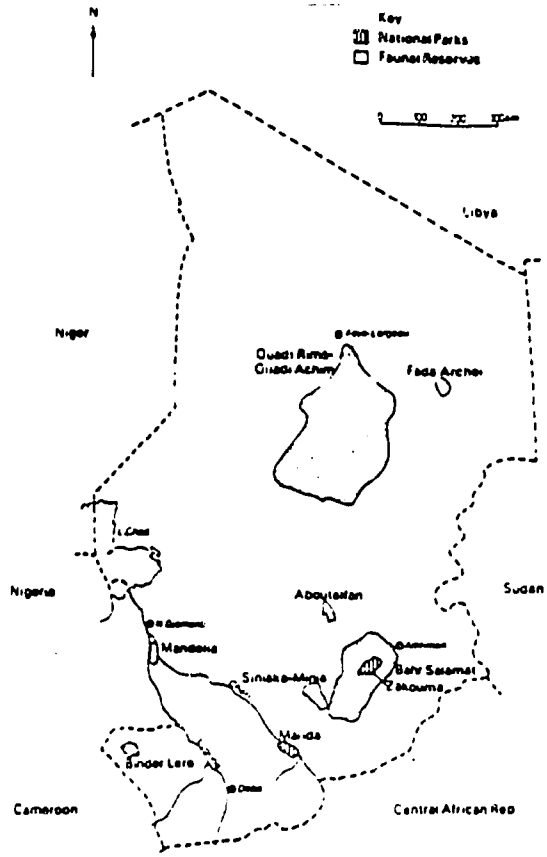
Near the headwaters of the Mayo-Kebbi, there is a vast plain containing the Touboiris and Loke marshes. These marshes, when flooded, contribute water to the Logone river. Likewise, when water in the Logone is very high, it crosses over into the marshes and flows down the Mayo-Kebbi river. The plain and adjacent areas on the Logone river are extensive areas of rice cultivation, some of which is irrigated and treated with insecticides.

The most scientifically important and vulnerable animals in the area are perhaps the landlocked, fresh-water manatees in Lake Léré and Lake Tréné. Nothing is known of this population, but its numbers have been estimated at between 100 and 150 individuals. The animals are fully protected, but we were told they are poached for food. It may be that the species still exists primarily because there are few motorized boats on the lakes to facilitate their capture. Waterfowl, waterbirds, pelicans, and other fish-eating birds use the lake, as it contains abundant fish from the Chad basin and the Niger river systems. The lake supports an important fishery that supplies the local markets, provides employment, and contributes to the local economy.

D4. National Parks and Faunal Reserves

Chad has two national parks and seven faunal reserves (see Map E-8 on the following page, IUCN 1987). In addition, Lake Fitri is a biosphere reserve and Lake Iro has been

Map E-8: The National Parks and Faunal Reserves of Chad



Source: IUCN 1987

nominated for that status. National parks and faunal reserves in Chad are administered by the Directorate of Parks and Reserves in the Ministry of Environment and Tourism. The directorate has four services—Park Management, the Ecobiology, Legislative and Contracts, and Personnel and Procurement. There are 36 employees of the directorate in N'Djaména and about 200, including laborers, in the field. The annual budget of the Directorate is 25 million CFA.

Conservation, wildlife protection, and hunting are governed by National Ordinance No. 16/63 of 1963, which is out of date and seldom enforced. Under Title 3, Chapter 1 of the Ordinance, 14 genera of mammals, 4 species of birds, and all vultures and crocodiles are given full protection. Some 30 species of mammals and 9 species of birds are given partial protection, but these include some species, such as the addax and oryx, now clearly endangered. There apparently is no legislation to protect birds of prey in Chad (Robinson, 1989).

There is a large, illegal trade in animal skins, especially of reptiles and amphibians (Kindler et al. 1989). Anecdotal evidence suggests animals are killed for food whenever possible and two decades of civil unrest have made guns available to many in the population.

Hunting and wanton shooting is perhaps the principal factor responsible for the disappearance of larger birds and mammals from more pristine areas of Chad.

Recently the GOC prepared a conservation and management plan for elephants (Tchad 1991b). The herds in Chad are claimed to have been reduced more that 80 percent by ten years of civil unrest. The plan lists the areas and numbers in which elephants now occur. Salamat Province—1500; Guéra mountains and Lake Fitri—500; Chari-Baguirmi prefecture —100; Lake Chad—100; West of Chari river—100; and Ouaddaï prefecture—perhaps a few. Areas where elephants persist probably are the most remote and pristine sites remaining in the southern part of Chad.

The Parc National de Manda (1140 km^2) was established in 1965 to protect the rare Giant Eland (*Taurotragus derbianus gigas*) and other wildlife. The woodland-savannah habitat is in reasonably good condition and presumably still supports its original complement of birds and small animals. All large mammals and the Ostrich are now gone, including the elands, which were shot out during the insurrections of the past two decades. A few droppings, and one inconclusive sighting, suggest that a few Bushbuck (*Tragelaphus scriptus*) and Grimm's Duiker (*Sylvicapra grimmia*) still survive. One herd of 50-60 cattle was seen grazing in the park, but human intrusion appears to be minimal. The park is a candidate for rehabilitation (Tchad 1989).

The Parc National de Zakouma (3000 km^2), established in 1963, has a rich fauna and has received considerable attention recently. The park has been seriously affected by political unrest and military poaching since 1975, but this has now largely been curbed and the park is being rehabilitated. There are plans by the EC to finance the extension of the buffer zone to the west of the park to include the Siniaka Minia Faunal Reserve. Much of the park and reserve is flooded during the wet season, and the area has extensive open grassy floodplains interspersed with Sudanese savannah woodland dominated by *Combretum* spp., *Anogeissus*, and *Terminalia* spp. It still contains about 1500 elephants, as well as buffalo, giraffe (*Giraffa camelopardalis*, Defassa waterbuck (*Kobus defassa*), topi (*Damaliscus korrigum*), lion (*Panthera leo*) and leopard (*Panthera pardus*). There is a very rich population of waterbirds, including many pelicans. The European Community (FED) has funded rehabilitation of the park and has provided a technical advisor, Jean-Luc Temporal, who has developed management plans and conducted wildlife censuses. There are 16 game guards in the park and poaching is minimal. A large faunal reserve, the Bahr Salamat, surrounds the park and offers it some additional protection. There are several programs to support rural development for villages in the reserve to help relieve pressures for human encroachment on the park and its resources. Villages were moved from the parks when they were established, through many peasants still feel they have rights to the areas (land is not privately owned in Chad and tenure is established by previous use). Additional parks have been proposed at Aouk and at Goz Beida (Tchad 1989).

The faunal reserves in Chad are Aboutelfan (1983; 1100 km^2), Bahr Salamat (1964; 20,600 km^2), Binder-Léré (1974; 1350 km^2), Fada Archei (1967; 2100 km^2), Mandelia (1983; 1380 km^2), Ouadi Rime-Ouadi Achim (1969; 80,000 km^2), and Siniaka-Minia (1961; 4260 km^2). Hunting is allowed in the southern half of the Bahr Salamat reserve and on the

adjacent Siniaki-Minia reserve. The condition of wildlife habitat in these reserves varies, but all could benefit from additional protection from human use and hunting, rehabilitation and, in some cases, reintroduction of extirpated animals. There are proposals for new faunal reserves at Bein Amer, Kélo, Larmanaye, Ngam, and Ndam (Tchad 1989). Reserves appear to have been established to protect a species or a group of species—elephants at Mandelia (which are now gone), Roan Antelope and Bubale Hartebeest at Binder-Léré, Addax and Oryx at Ouadi Rime-Ouadi Achim, and Barbary Sheep at Fada Archei. Most parks, reserves, and water areas were excluded from insecticide treatments during the 1986-1988 locust control campaign.

Several faunal reserves lie within the area that might be impacted by ATPRP. The Binder-Léré Faunal Reserve (1,350 km^2) encompasses the Gauthiot Falls and the two lakes in the 800-900 mm rainfall zone. It probably provides some measure of protection to larger fauna, but lack of time did not permit a visit to check what species are still present. The reserve formerly contained lion, leopard, hippopotamus, greater kudu, topi, bushbuck, and ostrich among the larger forms of wildlife, in addition to the manatees in the two lakes (IUCN 1987).

The Mandelia Faunal Reserve (1,380 km^2), located south of N'Djaména in the 600-800 mm rainfall zone, still preserves extensive tree cover; it was said (IUCN 1987) to comprise savannah woodland dominated by *Terminalia* spp., *Anogeissus* spp. and *Combretum* spp., but is now apparently largely *Acacia seyal* with some *Hyphaene thebaica*. It is allegedly subject to flooding from the Chari and Logone Rivers. The reserve was established to protect the 660 elephant that formerly occurred there, but it is now grazed and partially occupied, and has lost all its large mammals, to poaching which began in 1975. It is probable, however, that much of the original birdlife is still to be found, as is the case elsewhere in the savannah areas. The reserve is flanked by the paved road from N'Djaména to Sarh, so it will be affected by any increased traffic that ATPRP engenders. Traffic is likely to expedite woodcutting in the reserve unless the government evicts those persons who now reside there and steps up control of the area. Ideally, this reserve should be linked with those in adjacent Cameroon in keeping with OAU policy, especially for the benefit of the elephants that exist in the Waza and Kalamaloue National Parks.

E. Impacts of ATPRP on Wildlife

E1. Habitat Alteration through Clearing for Agriculture

The greatest wildlife effects of ATPRP probably will be from increases in the area of land used by humans (extensification) and in the intensity of farm management (intensification). Additional land probably will be cleared for agriculture, while grazing and cutting for firewood could increase on the remaining non-crop areas. Such land use would alter habitats, reduce their value to wildlife, and even eliminate vegetation essential for particular animals. For example, specific trees (*Isoberlinia doka*) are used by Giant Eland during certain seasons of the year. Cutting of large trees and destruction of seedlings by grazing could restrict the range and population size of the Eland. With enforcement of hunting laws, the Giant Eland could be reintroduced into Manda National Park, as the habitat

is in relatively good condition. If ATPRP results in deterioration of park habitat, the job of Eland reintroduction would become much more complicated and expensive. Agricultural extensification certainly will increase use of parks, forest and faunal reserves for crops, firewood gathering, and grazing—especially since law enforcement is lax.

Growth in the area used for agriculture could further reduce the quality and availability of habitats used by smaller birds and mammals. Reduced biodiversity can affect an upland ecosystem's microclimates and its maintenance of soil fertility (WRI 1992). Non-crop areas provide habitats for most of the millions of migratory passerines that move through Chad each spring and fall, as well as for many resident birds and mammals. Animals that depend on planted (rather than non-crop) areas usually feed on crops and are considered pests. With increases in agricultural use of land, therefore, both vertebrate and invertebrate pest problems will increase.

E2. Shortening of Fallow Cycles

If farmers see market demand and have the necessary labor to increase production, they may reduce the length of fallows, reducing the value of the land for wildlife. Biodiversity improves on fallow land as plants, plant litter, soil organisms, insects other invertebrates, and small vertebrates invade the disturbed sites. Such biotic development in turn supports birds and rodents that eat insects, plants, and seeds, and larger species that prey on birds and rodents, such as mongooses, jackals, owls, raptors, and vultures. Shorter fallow cycles would tend to reduce the diversity and abundance of wildlife on fallow lands.

E3. Intensification of Agricultural Management

Increased acreage can be expected in cereal grains, peanuts, and manioc in the extensive rain fed farming areas in the southern provinces. Intensification in those crops will occur only if tariff reforms greatly increase markets, prices, and profits. Conversely, intensification can be expected in the production of rice, beans, *pois de terre*, okra, tomatoes, onions, sorrel, peppers, squash, sesame, tobacco, and sugar cane. Those crops are primarily grown in recessional areas of flood plains and shorelines or under irrigation. They are relatively high-value crops from which farmers can more readily recoup their costs. Reduced tariffs and increased markets will make intensification more practical and profitable. However, the acreage planted in those crops is considerably less than that of the upland, rain fed areas. In irrigated gardens in the wadis of the Ouaddaï, Kanem, and Lac Prefectures, increased use of agrochemicals is already occurring (Matteson 1991 and 1992).

E4. Habitat Alteration Due to Water Pollution

Runoff and precolation from both irrigation and rainfall can pollute ground and surface waters. The highest concentrations of agrochemicals in surface waters usually occur during periods of maximum runoff and river flows (Richards and Baker 1992). Pollutants include minerals, sediments, organic particulates, fertilizers, herbicides, and insecticides either suspended or dissolved in water. Return flow water can carry fertilizers in amounts sufficient to enhance plant growth in lakes and streams. Herbicides can kill plants exposed

to waste agricultural water. Fertilizers and most herbicides are not highly toxic to wildlife, but over time they can alter aquatic habitats and reduce their carrying capacity for fish and wildlife populations. Loss of biodiversity reduces an aquatic ecosystem's ability to absorb pollution, cleanse water, and retain its stability (WRI 1992).

Waste agricultural water has caused severe habitat deterioration in many wetlands of the western United States. Fertilizers have increased growth of emergent plants and reduced the area of open water surface. Water enrichment has supported heavy algae growth that forms thick algal mats over extensive areas of open water in the summer. The algal mats and suspended sediments in water restrict sunlight penetration and the production of plants rooted in the bottoms of marshes and lakes. Thus, as the marshes eutrophfy they produce inedible cattails and algae, while submergent plants, like the various pondweeds favored by waterfowl, disappear. Algal decay reduces the dissolved oxygen content of water and, over time, most fishes and other aquatic organisms that require high levels of dissolved oxygen are eliminated. Benthic organisms (bottom-dwellers) such as chironomid larvae tend to increase with eutrophication, while other insect larvae and planktonic crustaceans tend to decrease.

E5. Toxicity Hazards of Insecticides

Direct toxicity from insecticides can kill invertebrates, fish, turtles, snakes, mammals, and birds. This reduces the abundance and diversity of both vertebrate and invertebrate organisms in wetlands. Concern has been expressed over the potential pesticide effects on migratory birds in West Africa (Balk and Koeman 1984 and Mullie et al. 1991) and Egypt (Mullie and Meininger 1985). The insecticides used in Chad are highly toxic to wildlife and cause mortality. The problem will not be a serious one in the near future as pesticide use is limited. But farmers on irrigated and shoreline farms usually stated that they would use more agrochemicals if they were available. Insecticide use in the future probably would be limited to high-value crops and in the aggregate should not result in severe, continuous hazards to fish and wildlife.

E6. Agrochemical Use in Chad

Farmers buy some of their agrochemicals (fenitrothion, the fungicide maneb, and fertilizers) from government agencies. They appear to use some CotonTchad agrochemicals on vegetables in their gardens. In addition, they purchase synthetic pyrethroids (cypermethrin, cyhalothrin, and deltamethrine) illegally from Nigeria (the products are illegal only because no import duties were paid). Apparently, there is no legal, retail source of agrochemicals in Chad. Rice farmers use the insecticides deltamethrine, malathion, fenitrothion, organochlorine, lindane, and a standard NPK fertilizer. It is not clear where farmers obtain information on pesticides and recommendations for pest control on their crops. There is no legislation in Chad dealing with pesticide registration, safety, or food residue tolerances. The UNDP and the Netherlands currently are in the process of drafting pesticide legislation for consideration by GOC.

The greatest use of agrochemicals at present is on cotton, because the agrochemicals are provided to farmers as part of their contract with CotonTchad. Likewise, professional recommendations for pest control (both chemical and integrated pest management, IPM) are available only for cotton farmers (CIRAD 1993). New cotton pesticides are tested for two years before they are recommended and released for use. For 1993 guidelines are available for use of several synthetic pyrethroids, several carbamates and organophosphates, and endosulfan on cotton. Fortunately, few of those products are likely to pollute surface waters. The pyrethroids and chlorpyriphos (a carbamate) are highly toxic to many aquatic organisms, while endosulfan is a notorious fish killer. Furthermore, endosulfan is a persistent organochlorine insecticide that should be replaced with an alternative compound. Monocrotophos (an organophosphate insecticide) was banned for use on cotton in Arizona and California because it consistently caused serious bird kills. However, bird mortality occurred primarily when cotton was irrigated, and irrigation is not practiced in cotton culture in Chad. Still, monocrotophos should be replaced; other effective and safer products are now available for cotton insect control. Use of pesticides and control of cotton pests throughout West Africa was reported and discussed in CIRAD (1992).

The Plant Protection Service of the Ministry of Agriculture provided a list of pesticides they received from 11 donor organizations between 1986-1990. Most apparently were donated for bird, rodent, and locust control. Many of the same insecticides were ones we found farmers using on their crops after purchasing them from ONDR. The Service's stocks of pesticides were said to currently be exhausted. The list included:

Vertebrate control agents		
ICI raticide (probably brodifacoum)	22,300	kg
Chlorophacinon	7,000	kg
Fenthion	3,000	l
Locust insecticides		
Fenitrothion	364,350	l
Chlorpyriphos	97,000	l
Bendiocarb	3,850	l
Propoxur powder	130,000	kg
Lindane powder	55,000	kg
Carbofuran granules	805	kg
Experimental locust insecticides		
Cypermethrin	4,650	l
Fenvalerate	1,000	l
Deltamethrine	609	l

In summary, agricultural extensification is likely to result in increased degradation of existing wildlife habitats through conversion of non-crop lands to agriculture, reduction of fallow periods, increased grazing pressure and livestock-wild ungulate competition, greater harvest of trees for firewood and other uses, and increased human encroachment on parks and reserves. Agricultural intensification will cause increased use of water for crops,

decreased amounts of water available for fish and wildlife habitats, increased water turbidity, increased sedimentation rates, increased water pollution with agrochemicals, increased eutrophication and reduced levels of dissolved oxygen in wetlands, with resultant fish and wildlife mortalities. The cumulative impact of these effects would be a decrease in the abundance and biodiversity of wildlife and the carrying capacity of their habitats within the project area.

F. Indicators of ATPRP Impacts on Wildlife and Their Habitat

Indicators are needed of possible effects of agricultural extensification and intensification on critical aquatic and upland habitats and on vulnerable wildlife species within the project area.

Habitats

- **Increased pollution and sediment loads in water of the Chari and Logone rivers.** Eutrophication of Lake Chad could occur with decreases in the water quality of those rivers. Deteriorating conditions in Lake Chad would indicate that similar problems could be occurring in Lake Léré and Lake Fitri.

- **Habitat degradation in upland sites.** Extensification of rain fed agriculture and increased human encroachment on national parks and on faunal and forest reserves could occur.

Reductions in the Number and Diversity of Vulnerable Species

- Waterfowl and other waterbirds on Lake Chad and Lake Fitri.
- Upland birds in Manda National Park and in habitats near villages.
- Manatees in Lake Léré.
- Fishes and the fishery in Lake Chad.

G. Monitoring

To help monitor the above indicators, the following actions should be taken:

- Establish the capability in the GOC to collect and analyze water samples from the Chari-Logone river system, Lake Chad, and Lake Fitri for sediments, water quality, and agrochemicals.

- Include Manda National Park and Binder-Léré Faunal Reserve in the program of vegetation sampling being proposed for villages in other annexes. Those efforts would depict trends in habitat deterioration and human encroachment in the park and reserve, as well as near villages.

- Provide funds for continued censuses of waterbirds on Lakes Chad and Fitri, perhaps by the Bureau International pour le Recherche sur les Oiseaux d'Eau.

- Provide necessary funds to enable annual censuses of upland birds in Manda National Park, the Binder-Léré Faunal Reserve, and near the six selected villages by ornithologists in Chad.

- Collect multiple samples to assess changes in benthic species (numbers of chironomid larvae in a given area of bottom muds) and plankton biomass (crustaceans and other invertebrates collected in a timed haul with a plankton tow net) while sampling water on Lake Chad and Lake Fitri twice a year.

- Collect data annually on mesh size of fish nets and relative abundance of different size classes of fish in catch of fishermen to follow status of fish populations in Lake Chad.

- Fund continued efforts to gather annual statistics on the status of fish and the fishery in Lake Chad, like the surveys conducted in earlier years by ORSTOM.

- Encourage and facilitate more complete data on annual sales and use of agrochemicals in Chad—see current data gathered by the Division de la Statistique Agricole, N'Djaména, in (Tchad 1992).

- Establish a scheme for reporting pesticide incidences (poisonings and mortalities) using ONDR, PVOs, and Peace Corps volunteers.

H. Recommendations for Prevention and Mitigation of Wildlife Effects

- USAID should provide technical assistance to educate farmers (through PVOs and ONDR) in IPM methodology for wadi, garden, flood plain, and irrigated agriculture (see Matteson 1991 and 1992 for IPM considerations in the ORT project).

- USAID should provide technical assistance to develop non-lethal techniques for controlling bird damage to crops. Farmers interviewed consistently stated bird damage was their principal pest problem. There will be increased use of lethal agents (Queletox-fenthion) unless alternatives are developed (see Tchad 1989).

- USAID should provide technical assistance for education in the safe use of pesticides. Farmers are completely without technical information on application methods, container disposal, pesticide storage, and crop residues at harvest. USAID-funded PVO projects are involved in the use of pesticides. USAID, thereby, probably becomes responsible for following their own regulations and EPA registrations.

- Efforts should be made to control and reduce the use of fire in management of vegetation in Chad. Education is needed on the benefits and detriments of burning at different times of the year and on general fire ecology (see Happold 1987 and

Warshall 1989 for discussions of fire ecology in West Africa). Currently, fire is needlessly destroying wildlife habitats and forest resources.

- Every possible incentive should be provided to the GOC to quickly establish additional parks and reserves to protect the last remnants of semi-pristine habitats in Chad from degradation. Most loss of habitats and wildlife populations has occurred during just the last 20 years. Most other valuable sites and vulnerable animals will be lost within the next 5-10 years.

- USAID should encourage GOC to participate in and adhere to international conventions protecting nature, endangered species, and critical habitats such as wetlands.

- USAID should provide technical assistance to the GOC in drafting new legislation to protect nature, parks, reserves, and wildlife. This effort should include listing endangered plants, fishes, birds, and mammals; no such list currently exists.

- USAID should encourage and assist in the Netherlands/UNDP project that is drafting pesticide legislation for GOC.

- Funds should be provided through one of USAID's research programs to conduct censuses and investigations on the status and life requirements of manatees in Lake Léré.

- Surveys are needed to determine the status of isolated fish populations in the springs and wetlands of the BET Provinces (see Le Barre 1989); the River Prinia and Marbled Teal at Lake Chad (see Fanshawe and Gretton 1989); the Black Rhino in Chad in the country that borders Cameroon's Bouba Ndjida National Park where Black Rhinos occur (see Happold 1987); the Cape Clawless Otter and the Spotted-necked Otter in Lake Chad (see Happold 1987); and to identify the areas used for nesting by Black Crowned Cranes that need protection from human intrusion during the reproductive season.

APPENDIX E-1
ENDANGERED AND THREATENED FAUNA AND FLORA OF CHAD

(Darrel C. H. Plowes, USAID, N'Djaména, March 1993)

The following species are likely to be at risk in Chad for various reasons. This list has been compiled from a variety of literature sources, together with personal observation of a cross-section of habitats in the southern half of Chad in 1992-93, and experience in Sudan in 1986-1990.

Some of these species are classified as Fully Protected under National Ordinance 16/63 of 1963 and are shown here with a double asterisk (**); other species are classified as "Partially Protected" and are shown here with a single asterisk (*). These official lists include several birds and animals that are not thought to be especially at risk at present (these are listed separately below). In addition, there are a few items in the list which apparently do not occur in Chad, and which should be deleted in revised legislation. Species are listed by their English, scientific, and French names, followed by their current status.

ENDANGERED MAMMALS

Black Rhinoceros/*Diceros bicornis***/Le Rhinocéros noir
- Probably extinct in Chad

Addax/*Addax nasomaculatus**/L'Addax
- Not recently seen—perhaps extinct in Chad

Scimitar-horned Oryx/*Oryx dammah*/L'Oryx algazelle
- Possibly now extinct in Chad

Dama Gazelle/*Gazella dama*)*/La Gazelle Dama
- A few survivors in Wadi Rime/W. Achim Reserve

Rhim or Slender-horned Gazelle/*Gazella leptoceros**/La Rhim
- Possibly still a few in Wadi Rime/W. Achim Reserve

Sitatunga/*Tragelaphus spekei**/Sitatunga; Guib d'eau
- Endangered by habitat destruction in and around Lake Chad by cattle and fishermen

Giant Eland/*Taurotragus derbianus gigas**/L'Elan(d) de Derby
- Formerly in Manda Park; now extinct there. It should be reintroduced when practicable

129

Cheetah/*Acinonyx jubatus**/Le Guépard
- A few left in Zakouma; probably eliminated elsewhere

Leopard/*Panthera pardus**/La Panthère
- Status unknown—unlikely to be many survivors outside Zakouma Park

Wild Dog/*Lycaon pictus*/Le Cynhyène
- Probably extinct outside Zakouma Park—only a few in the Park

Manatee/*Trichecus senegalensis***/Le Lamantin
- Perhaps 150 in Lakes Léré and Tréne

Barbary Sheep/*Ammotragus lervia**/Le Mufflon à manchettes
- Probably some in Tibesti/Ennedi region

Wild Ass/*Asinus africanus***/L'Ane sauvage
- Uncertain if still surviving in Tibesti/Ennedi region

ENDANGERED BIRDS

Sudan Bustard/*Otis arabs*/Grande Outarde Arabe
- Widely hunted—apparently very few are left. They are slow breeders.

Denham's Bustard/*Otis denhamii*/Outarde de Denham
- Same as above

Nubian Bustard/*Neotis nubia*/Outarde de Nubie
- Same as above

Senegal Bustard/*Eupodotis senegalensis*/Poule de Pharaon
- Same as above

Black-bellied Bustard/*Eupodotis melanogaster*/Outarde à ventre noir
- Same as above

RARE OR THREATENED MAMMALS

African Elephant/*Loxodonta africana***/L'éléphant d'Afrique
- 16000 in 1978, now about 2300 (1500 Salamat, 500 Batha-Guera, 100 Chari-Banguiri, 100 Lake Chad, 100 Région à l'Ouest du Chari, Ouaddai no data)

Hippopotamus/*Hippopotamus amphibius**/Hippopotame
- Very few left in Chari River and Lake Chad

Giraffe/*Giraffa camelopardalis***/Girafe
- Probably close to extinction outside Zakouma Park

Roan Antelope/*Hippotragus equinus**/L'Hippotrague; Antilope chevaline
- Same as above

Defassa Waterbuck/*Kobus defassa**/Le Cobe defassa; Le Cobe onctueux
- Same as above

Greater Kudu/*Tragelaphus strepsiceros**/Grand Koudou
- A small population in Zakouma, and probably also in the Guera mountains, but likely to be rare elsewhere, though a reasonably good survivor in populated areas

Lion/*Panthera leo*)*/Le Lion
- Probably extinct outside Zakouma Park

Spotted-necked Otter/*Lutra maculicollis*/La Loutre à cou tacheté
- Endangered by habitat destruction and fishing in Lake Chad, but status unknown

Cape Clawless Otter/*Aonyx capensis*/La Loutre à joues blanches
- Same as above

RARE OR THREATENED BIRDS

Ostrich/*Struthio camelus***/Autruche
- Widely hunted; still a few north of Mongo, and in Wadi Rime/W. Achim Reserve, and about 300-500 in Zakouma Park

Demoiselle Crane/*Anthropoides virgo*/Grue Demoiselle
- Small numbers have been observed at Lake Chad and Lake Fitri. These sites are therefore important as wintering quarters for this threatened bird.

Northern Ground Hornbill/Bucorvus abyssinicus*/Grande calao
- Limited by nesting sites in savannah areas: deforestation or selective cutting of large trees containing adequate sized holes would limit reproduction. Consumption of locusts sprayed with avitoxic pesticides could kill family parties in such areas. In most African countries these birds are venerated and are not molested.

Bateleur Eagle/*Terathopius ecaudatus*/Bateleur
- Occasionally seen—about one per 200 km

Martial Eagle/*Polemaetus bellicosus*/Aigle Martial
- Rare savannah species in Chad

African Fish Eagle/*Haliaeetus vocifer*/Aigle Pêcheur

- Rare along major rivers. If fish were contaminated by water-borne persistent agrochemicals, these eagles would be at risk.

Ayre's Hawk Eagle/*Hiraaetus dubius*/Aigle-autour d'Ayres

- Rare savannah species

Peregrine Falcon/*Falco peregrinus*/Faucon Pèlerin

- The steep peaks and crags necessary for breeding and perching are limited

Senegal Parrot/*Poicephalus senegalus*/Papagayo Senegalése; Youyou

- Jeopardized by deforestation and loss by woodcutting of dead trees for nesting

River Prinia/*Prinia fluviatilis*/Fauvette de Lac Tchad

- Restricted to Lake Chad area—only recently discovered: faces possible habitat loss

OTHER RARE OR THREATENED VERTEBRATE FAUNA

Nile Crocodile/*Crocodylus niloticus*/Le Crocodile du Nile

- Extensively hunted for skins; killed due to fear

Slender-snouted Crocodile/*C. cataphractus*/Le Crocodile à bec élancé

- Allegedly occurs in Chad, but doubtful if present here

African Rock Python/*Python sebae*/Python Africain

- Killed for skins, and because of fear of all snakes

Water Monitor Lizard/*Varanus niloticus*/Varan d'eau

- Skins popular in leather trade

Desert Tortoise/*Geochelone sulcata*/Grande Tortue de Sahara

- Status uncertain—possibly killed for meat

THE TIBESTI/ENNEDI ENDEMIC FISH POPULATION

Sixteen species of fish are said to occur in the wadis, lakes, and rock pools (guelta's) in the Tibesti and Ennedi massifs in the north of Chad; the majority of these are endemic. As these relic bodies of water are all very limited in extent, and as they occur in a fragile desert environment, all species of fish and other aquatic life that they contain should be regarded as vulnerable.

Other fish

A population crash of *Alestes baremoze*, the most prolific and prized fish of Lake Chad, has reportedly occurred, which is of considerable concern. The reason for this does not appear to have been established. The status of the Nile Perch (*Lates niloticus*) requires monitoring, as it is highly esteemed, and numbers appear to be limited. As both of these species are at the top of the aquatic food chain, they would probably be the worst impacted by accumulation of persistent agrochemicals if such were to come into widespread use.

RARE OR THREATENED FLORA

Borassus Palm/*Borassus aethiopum*/Le Rônier
- Wild Chadian population virtually eliminated for use as roofing beams

Desert Rose/*Adenium obesum*/Pied d'éléphant
- Scarce popular ornamental

Tropical Spotted Aloe/*Aloe macrocarpa*/Aloe tacheté tropicale
- One small colony known near Léré

Items Partially Protected Under Article 25 of the Chadian Wildlife Legislation, but which Are Not Included in the Above Lists

These are species whose status in Chad is thought to be reasonably secure at present either within or outside of existing parks, or else are species that do not occur in Chad and should not have been placed on the lists of Protected or Partially Protected species.

Mammals on Chad Protected List

Antbear/Aardvark/*Orycteropus afer*/Le Fourmillier
- Status uncertain, but is nocturnal, probably not hunted, and relatively widespread in savannah areas where termitaria occur

All Pangolins/*Manis, Phataginus, Smutsia*/Les Pangolins
- None are known to occur in Chad, but the Cape Ground Pangolin (*Smutsia temminckii*) is recorded in Central African Republic, so might possibly occur in adjacent areas of Chad

White Rhinoceros/*Ceratotherium simum*/Le Rhinocéros blanc
- This has never occurred in Chad

Fossa/*Cryptoprocta fossa*/Le Foussa
- This genet-shaped carnivore only occurs in Madagascar

Klipspringer/*Oreotragus oreotragus*/Oréotrague
- Not known in Chad

African Buffalo/*Syncerus caffer*/Le Buffle d'Afrique
- Still common in Zakouma Park, though probably largely eliminated elsewhere

Dorcas Gazelle/*Gazella dorcas*/La Gazelle dorcas
- Apparently still in reasonable numbers in semi-desert areas—a good survivor

Red-fronted Gazelle/*Gazella rufifrons*/La Gazelle à front roux
- Common in Zakouma, and probably surviving in less populated savannah areas elsewhere

Western Kob/*Kobus kob*/Le Cobe de Buffon
- Common but localized in Zakouma—possibly still on isolated floodplains elsewhere

Bohor Reedbuck/*Redunca redunca*/Cobe des roseaux; Redunca
- Common in eastern Zakouma, and probably also in undisturbed areas in Salamat

Topi or Korrigum/*Damaliscus lunatus korrigum*/Le Damalisque
- Very common in eastern Zakouma, and probably still on adjacent unoccupied savannah and floodplains

Chad Bubal Hartebeest/*Alcelaphus busephalus tschadensis*/Le Bubale tchadien
- Very common in Zakouma, and probably also in unoccupied savannah

Bushbuck/*Tragelaphus scriptus*/Le Guib harnaché
- Locally common in Zakouma, possibly still a few in Manda Park, and probably in riverine thickets in less populated areas—a good survivor

Serval/*Leptailurus serval*/Le Serval
- Probably widespread on floodplains and near rivers—a good survivor

<u>Birds on Chad Protected List</u>

Shoebill Stork/*Balaeniceps rex*/Bec en sabot
- Never recorded from Chad

Bald Ibis/*Geronticus eremitra*/Comatibus chevelu
- Never recorded from Chad

Secretary Bird/*Sagittarius serpentarius*/Messager serpentaire
- Widespread, but not common, in open savannah; no known threats

All the Vultures/*Gyps* and allied genera/Tous les Vautours

- All species appear to be holding their own, but the White-headed Vulture (*Trigonoceps occipitalis*—Vautour Huppé) is the least common. The spectacular Palm-nut Vulture (*Gypohierax angolensis*—Vautour Palmiste) does not appear to have been recorded in Chad, but oil palms (*Elaeis guineensis*), which are the principal food source for these dramatic birds, are said to occur in the southern regions of Chad, they may possibly be found there at times. If these palms do occur in southern Chad, then any felling of oil palms for logs would be the main danger to their continued existence there. However, the present decrease in rainfall and the southward shift of the 1200 mm isohyet south of Chad would suggest that the Palm-nut Vulture is no longer likely to occur here.

Cattle Egret/*Bubulcus ibis*/Héron garde boeufs

- Very common and widespread and in no danger. A child was seen in N'Djaména with some fledglings from a heronry in the city, so they are apparently eaten at times.

Little Egret/*Egretta garzetta*/Aigrette garzette

- Found in small numbers along all rivers and lakes

Yellow-billed Egret/*Egretta intermedia*/Aigrette intermédiaire

- Widespread, but not as frequent as the Little Egret

Great White Egret/*Casmerodius alba*/Grande aigrette

- Occasional along rivers and lakes

Marabou Stork/*Leptoptilus crumenifer*/Marabout

- Common, especially near water

Saddlebill Stork/*Ephippiorhynchus senegalensis*/Jabiru

- Sparingly spread along rivers, lakes, and open flooded areas

All Pelicans/*Pelecanus* spp./Tous Pélicans

- Both the Pink-backed Pelican (*P. rufescens* - Pélican gris) and the White Pelican (*P. onocrotalus* - Pélican blanc) are widespread on the lakes and suitable stretches of major rivers. The latter species breeds in winter (perhaps 200-400 pairs) on the inaccessible summit of the granite peak Ab Touyour near Bitkine. Neither species is under threat.

APPENDIX E-2
REFERENCES

Ash, J.S., I.J. Ferguson-Lees, and C.H. Fry. 1967. B.O.U. Expedition to Chad. Ibis 109:478-486.

_____, and R.E. Sharland, 1987, "Nigeria: Assessment of Bird Conservation Priorities," ICBP Study Report No. 11. 59 pp.

Balk, I. F. and J. H. Koeman. Future hazards of pesticide use with special reference to West Africa and Southeast Asia. IUCN Commission on Ecology Papers No. 6. Gland, Switzerland.

Blache, J., 1964, *Tome II: Les poissons du bassin du Tchad et du bassin adjacent du Mayo Kebbi: Etude systématique et biologique.* 485 pp. 147 pp.

_____, and F. Miton, 1963, *Tome I: Première contribution à la connaissance de la pêche dans le bassin hydrographique Logone-Chari-Lac Tchad.* Mémoires ORSTOM 4, 144 pp.

Boere, G.C. 1991. The Bonn Convention and the conservation of migratory birds. ICBP Technical Publication 12: 345-360.

CIRAD, 1992. Réunion de coordination de recherche phytosanitaire en culture cotonnière pour la sous-région Afrique. Revue Scientifique du Tchad II (1 and 2). 220 pp.

_____, 1993, "Rapport des recommendations phytosanitaires de la culture cotonnière pour la campagne 1993," CIRAD-CA/IRCT, N'Djaména, CHAD 11 pp.

Clements, J.F., 1991, *Birds of the World: A Checklist.* (Vista, California: Ibis) 617 pp.

Collar, N.J. and S.N. Stewart, 1988, "Birds to Watch: the ICBP World Check-List of Threatened Birds." ICBP, Cambridge.

Dejoux, C. 1968. "Le Lac Tchad et les chironomodes de sa partie est." Ann. Zool. Fenn. 5: 27-32.

Dowsett, R.J. 1969. B.O.U. supported research at Lake Chad in 1968. Ibis 111:449-452.

_____, 1969. Migrants at Malam'Fatori, Lake Chad, autumn 1968. Nigerian Ornith. Soc. Bull. 6: 39-45.

_____, 1969. Additions and amendments to the list of birds of Malam'Fatori, Lake Chad. Nigerian Ornith. Soc. Bull. 6: 53-55.

Dorst, J. and P. Dandelot, 1970, *A Field Guide to the Larger Mammals of Africa.* (London: Collins) 287 pp.

Ernst, C.H. and R.W. Barbour, 1989, Turtles of the World. (Washington, D.C.: Smithsonian Institution Press) 313 pp.

Fanshawe, J. and A. Gretton, 1989, "Africa Action Plan, Priorities for the ICBP Conservation Program," (Girton, Cambridge: ICBP) 54 pp.

Fortin, D., M. Lô and G. Maynart, 1990, Plantes Médicinales du Sahel," (Montreal and Dakar: C.E.C.I).

Fry, C.H., J.S, Ash and I.J. Ferguson-Lees. 1970. Spring weights of some palearctic migrants at Lake Chad. Ibis 112.

Golding, F.D. 1934. Notes on some birds of the Lake Chad area. Ibis 76.

Goodman, S.M. and P.L. Meininger. 1989. The Birds of Egypt. Oxford Univ. Press. Oxford, England. 551 pp.

Groombridge, B., 1982, *The IUCN Amphibia-Reptilia Red Data Book: Part I.* (Gland, Switzerland: IUCN) 426 pp.

Happold, D.C.D., 1987, *The Mammals of Nigeria.* (Oxford: Clarendon Press) 402 pp.

Hecht, J.E., 1993, "Elaboration d'un programme national de connaissance et suivi des ressources naturelles," Rapport pour la CTA/PDLCD, Ministère du Tourisme et de l'Environnement, N'Djaména, Tchad, 47 pp.

Hopson, A.J. 1965. Preliminary notes on the birds of Malamfatori, Lake Chad. Nigerian Ornith. Soc. Bull. 1:80-90.

IUCN, 1986, *Plants in Danger—What do we Know?* (Gland, Switzerland: IUCN).

_____, 1987, "IUCN Directory of Afrotropical Protected Areas," (Gland, Switzerland: IUCN).

Kindler, J., P. Warshall, E. J. Arnould, C. F. Hutchinson and R. Varady, 1989, "The Lake Chad Conventional Basin: A Diagnostic Study of Environmental Degradation," Report prepared for the UN Environment Program and UN the Sudano-Sahelian Office by the Office of Arid Lands Studies, University of Arizona, Tucson AZ, 182 pp.

King, W.B., 1981, *Endangered Birds of the World—the ICBP Bird Red Data Book.* (Washington, D.C.: Smithsonian Institution Press).

Kusnir, I. 1993 Geology, ressources minérales, et ressources en eau du Tchad. Centre National d'Appui à la Recherche. N'Djaména, Tchad.

LaVoie, G.K., 1989, "Rodent Pests of Agriculture in Sahelian Africa," Unpublished report on file at the Denver Wildlife Research Center, U.S. Department of Agriculture, Denver, Colorado. 19 pp.

Le Berre, M., 1989, *Faune du Sahara—1: Poissons, amphibiens, reptiles.* (Paris: Lechevalier-R. Chaubaud) 332 pp.

_____, 1990, *Faune du Sahara—2: Mammals.* (Paris: Lechevalier-R. Chaubaud) 360 pp.

Lebrun, J.-P., et al, 1972, "Catalogue des plantes vasculaires du Tchad méridional" (France: Maisons-Alfort).

_____, 1976, Premier supplément au "Catalogue des plantes vasculaires du Tchad méridional" (France: Maisons-Alfort).

_____, 1977, Deuxième supplément au "Catalogue des plantes vasculaires du Tchad méridional" (France: Maisons-Alfort).

Le Houérou, H.N. and H. Gillet. 1986. Conservation versus desertification in African arid lands. In: M.E. Soule ed. Conservation Biology: the Science of Scarcity and Diversity. pp. 444-461.

Matheson, C., 1986, *Snakes of the World.* (New York: Facts on File Publications) 190 pp.

Matteson, P.C. 1991/92, "Integrated Pest Management for Vegetables in Irrigated Wadis, Ngouri Sub-Prefecture, Chad" Third Mission Report, 29 pp. and Final Report, 38 pp. American ORT Federation, N'Djaména.

Moreau, R.E., 1972, *The Palearctic-African Bird Migration Systems.* (New York: Academic Press) 384 pp.

Mullie, W.C. and P.L. Meininger. 1985. The decline of bird of prey populations in Egypt. ICBP Technical Report 5: 61-81. Cambridge, England.

Mullie, W.C., P.J Verwey, A.G. Berends, J.W. Everts, F. Sene, and J.H. Koeman. 1991. The impact of pesticides on palearctic migratory birds in the western Sahel. ICBP Technical Publication 12: 37-61. Cambridge, England.

Nelson, J.S., 1976, *Fishes of the World.* (New York: John Wiley and Sons) 416 pp.

Newby, J.E. 1979/1980. "The Birds of the Ouadi Rime—Ouadi Achim Faunal Reserve: A Contribution to the Study of the Chadian Avifauna" *Malimbus.* 1:90-109 and 2:29-50.

Ozenda, P., 1977, *Flore du Sahara* (Paris: Centre National de la Recherche Scientifique).

Pias, J., 1970, *La Végétation du Tchad.* (Paris: ORSTOM).

Pousset, J.-L., 1989 and 1992, *Plantes Medicinales Africaines.* (Paris: ACCT, Ellipses).

Richards, R.P. and D.B. Baker, 1992, "Pesticide Concentration Patterns in Agricultural Drainage Networks in the Lake Erie Basin" *Environmental Toxicology and Chemistry* 12:13-26.

Robinson, P.J. 1989. The legal status of diurnal birds of prey in Africa. In: Raptors in the Modern World. B.-U. Meyburg and R.D. Chancellor eds. WWGBP. Berlin. pp. 577-590.

Roux, F. and G. Jarry, 1984, "Numbers, Composition and Distribution of populations of *Anatidae* Wintering in West Africa" *Wildfowl.* 35:48-60.

Salvan, J., 1967-8, "Contribution à l'étude des oiseaux du Tchad" *L'Oiseau et R.F.O.* 37:255-284; 38:53-85.

Seignobos, C. 1979, "Completion of Range Surveys in Lake Chad Basin, 193-216" (N'Djaména, Commission du Bassin du Lac Tchad).

Serle, W., G.T. Morel, and W. Hartwig, 1977, *The Collins Field Guide to the Birds of West Africa.* (Lexington, Massachusetts: The Stephen Green Press) 351 pp.
Tchad, République du, 1987, "Géographie du Tchad: cours moyen," Ministère de l'Education Nationale, EDICEF, Paris. 47 pp.

Tchad, République du, 1989, "Plan directeur de lutte contre la désertification," Ministère du Tourisme et de l'Environnement, N'Djaména. 122 pp.

Tchad, République du, 1991a. *Annuaire hydrologique de la République du Tchad, Année 1988-1989.* Programme AGRHYMET—Service Hydrologique, Direction des Ressources et Eau et de la Météorologie, MMERE, N'Djaména. 146 pp.

Tchad, République du, 1991b, "Plan de conservation de l'éléphant au Tchad," Ministère du Tourisme et de l'Environnement, N'Djaména. 49 pp.

Tchad, République du, 1992 *Annuaire Statistique 1991,* Division de la Statistique Agricole, Ministère de l'Agriculture. N'Djaména. 105 pp.

Thiollay, J.M., 1975. "Les rapaces des Parcs Nationaux du Tchad méridional" *L'Oiseau et R.F.O.* 45:27-40.

Tolba, M.K., 1992, "A Plan for Lake Chad" *GRID News*. 5:1.

USAID, 1991, "Supplemental Environmental Assessment of the Locust/Grasshopper Control Program in Chad," N'Djaména. 61 pp.

USAID, 1992, "Initial Environmental Evaluation—ATPRP (667-0069)," N'Djaména, Chad. 13 pp.

Vielliard, J. 1972. Recensement et statut des populations d'anatides du Bassin Tchadien, Cah. ORSTOM ser. Hydrobiol. VI; 85-100.

_____, 1974, "Les chiroptères du Tchad," *Revue Suisse Zoologique*. 81:975-991.

Wake, D.B. and A.G. Kluge, 1961, "The Machris Expedition to Tchad, Africa: Amphibians and reptiles," Los Angeles County Museum Contribution to Science No. 40. 12 pp.

Wanzie, C.S., 1990, "Water Resources Management (WRM) and Wildlife Management in the Lake Chad Basin" Mammalia. 54:579-585.

Warshall, P., 1989, "Mali Biological Diversity Assessment," report prepared for USAID Africa Bureau, Washington, D.C., by E/DI, Washington, D.C. and Office of Arid Land Studies, University of Arizona, Tucson, Arizona. 95 pp.

Wells, S.M., R.M. Pyle and N.M. Collins, 1989, *The IUCN Invertebrate Red Data Book.* (Gland, Switzerland: IUCN) 632 pp.

World Resources Institute, IUCN, UNEP. 1992. Global biodiversity strategy. World Resources Institute. Washington, D.C., 244 pp.

ANNEX F

PERSONS CONTACTED; SCOPE OF WORK

ANNEX F
PERSONS CONTACTED

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M. Daboulaye Ban Ymary	Directeur des Parcs et Réserves de Faune
M. Laboudang	Agent Forestier, Léré

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M. Banboh Elvan	Directeur des Routes

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17 March, 1993

Dr. Joy F. Hecht
Team Leader
ATPRP Environmental Profile

Dear Dr. Hecht:

This letter is to confirm our discussion on February 26 concerning the scope of work and the outline presented by the Chemonics team for the environmental profile report. As we agreed verbally, the Mission will only hold the team responsible for carrying out the ATPRP environmental profile SOW insofar as it concerns the impacts of ATPRP tariff reforms on the environment. It will not hold the team responsible for work related to broader environmental or natural resource considerations beyond the scope of ATPRP. The Mission anticipates that a report which covers the material in the outline presented on February 26 should satisfy these requirements. Approval of the team's work will, of course, be based on the final report submitted at the end of the mission.

Sincerely yours,

Carole Palma

Carole Palma
Assistant AID
Representative

205

Scope of Work for ATPRP Environmental Inventory

BACKGROUND

Program Description

The Agricultural Trade Policy Reform Program (ATPRP) is intended to improve the quality of life of the rural population through sustained and broad-based, market-oriented growth in agricultural production (the program goal). Specifically, the project will seek to increase the efficiency of Chad's agricultural marketing system for non-industrial crops (the program purpose). This is to be achieved through the reform of government policies that increase marketing costs and restrict markets. The proposed ATPRP reform program consists of:

- the reduction of import duties on trucks and spare parts;
- the reduction of import duties on agricultural inputs;
- the elimination of export taxes on agricultural products; and
- the simplification or elimination of export licensing requirements for agricultural products.

The ATPRP also has an export market development project component to assist and expedite private sector response to the improved marketing environment as it relates to exports.

Indicators to be used to measure program purpose achievement are.

- Transporters will have improved their truck fleets (buy new and used vehicles, repair older ones, etc.) thus reducing transportation costs and increasing Chadian capacity to transport agricultural products.
- The number of agricultural marketing firms registered in the formal sector will have increased.
- There will have been a shift in exports of agricultural commodities to Cameroon, Nigeria, and the CAR from unofficial channels to official channels.
- The private sector will have increased its sales of fertilizers, improved seeds, and agricultural equipment (carts, plows) to farmers.

206

- Farmers with reliable and profitable markets for their increased production, (i.e., farmers with good road access to markets in neighboring countries), will have adopted improved production technologies.

There are two important assumptions that must be met for program interventions to achieve the program purpose. The first is that participants in the agricultural marketing system will start operating on a larger scale and in some cases even move into the formal sector. First, this implies that there are economic benefits to becoming more visible, such as economies of scale or increased access to larger markets, and second, that the remaining disincentives to becoming more visible, especially taxes, are not perceived as excessively onerous. The second assumption is that available improved technologies provide adequate returns to the farmer with acceptable risks.

Indicators to be used to measure program goal achievement are:

- Agricultural exports to neighboring countries will have increased.

- Farmers in producing regions with road access to export markets will have increased their marketed production.

- Traders will be paying higher producer prices as a result of lower transportation costs and expanded more lucrative export markets.

- Incomes of traders and transporters will have increased as a result of reduced marketing costs and increased marketing volume.

There are three key assumptions for the achievement of the program goal. The first is that there are export markets where Chadian products can be competitive that are large enough to absorb sustained increases in marketable surpluses. The second is that the production systems of Chadian farmers can produce dependable supplies of agricultural products for relatively large established markets. The third is that the primary road network continues to be adequately maintained.

The Impact Monitoring Plan

The magnitude of changes at the purpose and goal level cannot be precisely predicted because they will occur as the private sector participants -- farmers, wholesalers, transporters, and exporters -- respond to changes in the policy environment. As formal sector businesses become more active in agricultural marketing and informal sector businesses start operating on a larger scale in response to the improved policy environment, changes in the indicators listed above will be measurable for specific crops in specific locations. For this reason, impact estimates at the national level will have to be largely extrapolated from changes observed in specific locations for specific crops in response to program interventions.

The impact monitoring program will consist of setting up benchmarks for each of the purpose and goal indicators, measuring annual changes in these indicators through the life of the program, and relating these changes to ATPRP interventions. This will be achieved by 1) collecting pertinent data from existing sources, including government statistics, 2) carrying out in-depth key informant surveys in project years 4, 5 and 6 of a small number of traders and farmers in areas most likely to be affected by the policy reforms, and 3) carrying out rapid rural reconnaissance surveys in project years 4 and 6 of a relatively large cross-section of traders and farmers in these same areas as a basis for applying the results of the key informant surveys to the general population in the regions surveyed.

The impact monitoring strategy is to focus attention on those commodities, areas, traders, and farmers likely to be most affected by changes in the policy environment. This is necessary because, 1) most national-level data is not easily retrievable and is generally unreliable, and 2) very little, if any, measurable private sector response at the national level will have occurred by the end of the program. By focussing on where program impact is most likely to happen first it will be possible to measure and document the impact of policy reforms and the process by which private sector participants respond. This information can then be used to project the nature, and to a large extent the magnitude and location, of the long-term changes that are likely to occur after the end of the program.

Annex F of the PAAD describes the ATPRP impact monitoring plan in detail and should be referred to in responding to this scope of work. Impact monitoring will consist of a baseline study to establish benchmarks against which program impact is to be assessed, and key informant and rapid reconnaissance surveys to measure changes in the impact indicators over the life of the program. Project monitoring will also focus on environmental impacts, if any. An environmental inventory will be undertaken as soon as possible after the signing of the grant agreement in order to assess Chad's natural resource base. After this has been completed, the ATPRP institutional contractor will provide an applied ecologist to participate in the 5/94 baseline/benchmark study as well as the key informant and RRR surveys.

The contractor shall provide specialists to perform the following tasks:

1. gather information on relevant environmental and natural resource issues in Chad by using techniques such as literature searches, discussions and interviews, surveys, field investigations, and by reviewing manuals, documents, and current relevant periodicals;

2. obtain information from the USAID mission, PVO/NGO organizations, government ministries, interested conservationists, other Government agencies, Multi-lateral Development Banks, regional organizations, and concerned individuals regarding environmental and natural resource conditions, status and issues;

3. review information, evaluate it and obtain any additional information required to provide a complete and coherent understanding of the current ENR status in Chad. The contractor shall define the issues, highlight problems, set priorities, and provide

direction for future efforts intended to manage, conserve, and rehabilitate the environment and the natural resource base in Chad;

4. identify several indicators or proxy indicators of change for each priority ENR concern, suggest acceptable limits for test values, and describe thoroughly the places of testing, testing protocols, testing frequency, and equipment required to collect samples and perform analysis. The contractor shall perform any appropriate ecological risk analysis or assessment required in order to establish significant, de minimus, or reasonable risk criteria for adverse environmental impacts which can be identified or forecast based on currently available information;

5. The contractor shall prepare a comprehensive environmental and natural resource profile of Chad based upon currently available and derived sources of data. The goal is to understand the problems and their magnitudes, understand the processes of change, establish a starting point for baseline measurements, inventory existing data and data sources, provide in-depth analysis where data is sufficient, and indicate where data gaps exist. Topics to be summarized shall include but not be limited to: geography, topography, demography, economy, education, health, institutions, civil war, and foreign aid. Topics considered in detail shall include but not be limited to: geology and geomorphology (minerals, soils), climatology and hydrology (groundwater, surface water use, water law), land capability and use practices (wind erosion, water erosion, laterization, declining fertility, agricultural practices, transhumance, shifting cultivation, carrying capacities, marginal lands, land tenure), flora (desert, range, forest, unique exotic pests), fauna (mammals, birds, reptiles, amphibians, fish, invertebrates, pests), biological diversity (fragile areas, threatened and endangered species, endemics, critical habitat, habitat loss, protected areas, gap analysis, niches, limiting factors) and energy.

6. assess the need to preserve, conserve, inventory, recover, rehabilitate, restore, manage, re-introduce, gene-bank, buffer, corridor, and monitor individual species, food-webs, ecosystems, habitat, fragile, sensitive, vulnerable, rare and insufficiently known resources. The contractor shall assess the severity of the problem, suggest corrective technical options, propose appropriate actions, suggest possible timing, and forecast other support systems.

7. suggest items needing additional research, where recovery plans should be prepared, which resources are currently overexploited, which are underexploited, where management is needed, where management can be improved, where alternative resources should be used, what alternatives are available and practical, and what other action planning should be initiated;

8. write, collate, edit and prepare the draft environmental profile study document for USAID/Chad review and comment;

9. revise, edit, and oversee document preparation of the final approved version of the Chad environmental profile study..

201

DELIVERABLES

No later than three days after the Team Leader's arrival in Chad, the team will present to USAID/Chad a detailed outline of the Report they intend produce, including tables and appendices. Indication should be given as to who will be responsible for each section. USAID will provide oral comments on various drafts of the document. The final typed draft in English will be presented to USAID/Chad prior to the team leader's departure from Chad. USAID will provide written comments to the contractor prior to the team's departure. Upon finalization of the document and acceptance by USAID, the contractor will be authorized to publish and translate the document. The contractor will express mail (DHL) 10 copies of the finalized document in both English and French, with diskette(s) containing the both document files, using WordPerfect 5.0/5.1, approximately 10 days following the team's departure from Chad.

PERIOD OF PERFORMANCE

It is envisioned that the work in Chad will begin o/a January 15, 1993 and will last for 8 weeks. All team members should plan to arrive simultaneously, therefore any literature searches which may need to be performed in the U.S. should be undertaken in advance of the team's arrival at post. Bob Hanchett, the REO, will participate in this activity during the first and final two weeks.

TECHNICAL ASSISTANCE EXPERTISE REQUIREMENTS:

1. Regional Planning
2. Botany/Forestry
3. Zoology/Range Management
4. Hydrogeology/Soil Science
5. Biological Diversity
6. Ecology/Agronomy

USAID/Chad will provide 2 biodiversity specialists: Bob Hanchett, the Regional Environmental Officer based in Abidjan and Darrel Plowes, a local-hire recruited for this activity. The mission would prefer to minimize the team size and hence collapse as many disciplines as possible into the minimum amount of people. We foresee the need for a Team Leader who has expertise in one of the 5 remaining disciplines, as well as 2-3 other technicians.