A3.3 LEG 1991

PN-ADA-164

Return to ANRE Resource Center
USAID/AFR/SD

SUPPLEMENTAL ENVIRONMENTAL ASSESSMENT

OF THE

LOCUST/GRASSHOPPER CONTROL PROGRAM

IN MALI

United States Agency for International Development

Mission to Mali

In cooperation with the Government of the Republic of Mali

Bamako, Mali

May 1991

SUPPLEMENTAL ENVIRONMENTAL ASSESSMENT

OF THE

LOCUST/GRASSHOPPER CONTROL PROGRAM

IN MALI

United States Agency for International Development

Mission to Mali

In cooperation with the Government of the Republic of Mali

Bamako, Mali

May 1991

TABLE OF CONTENTS

Section	page
List of Tables and Figures	iii
List of Appendices	iv
Acronyms and Abbreviations	vi
Preface	ix
Acknowledgements	ix
1.0 EXECUTIVE SUMMARY	1
2.0 PURPOSE AND PROCEDURES	4
2.1 Procedure to Determine Scope	5
2.2 Previous Assessments	5
2.3 Analysis and Document Preparation	6
3.0 ENVIRONMENTAL REGULATIONS	7
3.1 A.I.D. Environmental Procedures	7
3.2 Environmental Regulations in Mali	7
4.0 COUNTRY AND SITUATION DESCRIPTION	11
4.1 Physical Environment and Meteorology	11
4.2 Agroecological Zones of Mali	13
4.3 Agricultural Resources Threatened: Loss Assessment	17
4.4 Locust and Grasshopper Characteristics	28
5.0 CONTROL OPERATIONS IN MALI	33
5.1 Crop Protection Service and Other National Agencies	34
5.2 Training for Control Operations by the CPS	38
5.3 Control Operations and Approaches at National Level	41
5.4 Donor Operations and Decision-making	45
5.5 Alternative Methods of Locust/Grasshopper Management	51
6.0 SELECTION AND MANAGEMENT OF PESTICIDES	55
6.1 Pesticides of choice	56
6.2 Safety Precautions	59
6.3 Current Pesticide Management Practices	60
6.4 Disposal of Outdated Pesticides and Empty Pesticide Containers	63

7.0 EVALUATION OF THE IMPACT ON HUMAN HEALTH 66

7.1 Target Populations 67
7.2 Public Health Delivery System 68
7.3 Evaluation of Risks of Pesticide Poisoning 71
7.4 Education and Training of the Target Population 72
7.5 Exposure Monitoring 73

8.0 NATURAL ENVIRONMENT AND NON-TARGET ORGANISMS 75

8.1 Natural Resources and Economy 75
8.2 Biotic Zones of Mali 75
8.3 Sensitive Environmental Regions with respect to Pesticide Use 78
8.4 Non-target Organisms and Endangered Fauna 80
8.5 Ecotoxicological Studies 85

9.0 SUMMARY FINDINGS, RECOMMENDATIONS AND OPTIONS FOR ACTION 89

9.1 Monitoring 91
9.2 Legislation, Policy and Safety 92
9.3 Survey and Crop Loss Assessment 92
9.4 Education, training and techncial support 93
9.5 Control Operations and IPM Alternatives 94
9.6 Pesticide Management and Disposal 95
9.7 Options for USAID in Implementation 96

10.0 BIBLIOGRAPHY 99

LIST OF TABLES AND FIGURES

Tables

page

Table 1. Actual Cereal Production during the 1988-89 Agriculture Year 24

Table 2. Forecast for the cereal harvest (1988/89) 25

Table 3. Revised Assessment of Millet and Sorghum Production after the grasshopper outbreaks of 1985 25

Table 4. Assessment of grasshopper-induced losses in millet and sorghum, with an overview of egg-pod density in the field in 1985 26

Table 5. Obsolete Pesticide Stocks and Pesticide Containers: Situation in Mali as of January 1990 64

Table 6. Feasibility of Options for Pesticides Disposal 65

Table 7. Broad Categories of Health Personnel per Capita, per Region in Mali in 1987 68

Table 8. Birds Protected by Mali Law 80

Figures

Figure 1. Map of Mali, with regions and capitals. 12

Figure 2. Bio-Climatic and Agroecological Zones of Mali. 16

Figure 3. Major Crop Growing Regions in Mali 20

Figure 4. Recession Breeding Areas of the Desert Locust in Mali 28

Figure 5. Plague Breeding Areas of the Desert Locust in Mali 29

Figure 6 Decision-tree for Sponsors of Crop Protection Activities 47

Figure 7 Map of protected areas and biotic zones in Mali 81

Figure 8. Protected Areas in relation to Areas of Particular Pesticide Use in Mali. 82
- a. Protected Areas and Elephant Ranges.
- b. Cercles in which Locust and Grasshopper Control Activities were greatest in 1988.
- c. Areas of Pesticide Use for Vector Control in Human Health Programs.

Figure 9. Representative Biological Resources at Risk. 83
- a. Major Migratory Flyways for Eurasian Birds into Africa.
- b. RAMSAR Convention-designated sites of biological significance in the Mali Interior Delta

LIST OF APPENDICES

Appendix A. List of Preparers and Persons Interviewed

Appendix B. Programmatic Environmental Assessment (PEA) for locusts/grasshoppers:
- B.1. Synopsis of the Environmental Assessment Priorities
- B.2. Disposition of the 38 Recommendations in the PEA: Basic Pre-condition of Program

Appendix C. Pesticides that can be Provided with U.S. Assistance

Appendix D. Supporting Materials Related to Past and Future Campaigns against Grasshoppers and Locusts:
- D.1 Insecticides Used By the Crop Protection Service During the Agricultural Campaigns of 1985-1986 to 1989-1990.
- D.2 Equipment and Pesticide Needs for Phase I of the 1989/90 Campaign.
- D.3 Evaluation of Storage Conditions for Pesticides in Mali.
- D.4 Crop Protection Service Campaign Plan 1990/91.
- D.5 Summary of Risks and Benefits of the 1985 Campaign.
- D.6 Background, Structure, Organigram of the Crop Protection Service in Mali as of 1989 (in French).

Appendix E. Documents Related to Disposal of Obsolete Pesticides in Mali
E.1 Action Plan: Disposal of Obsolete Pesticides and Their Containers in Mali
E.2 Quantities of Obsolete Pesticides

Appendix F. Checklist of Birds of Mali, including Key Dietary, Migration and Habitat Data

LIST OF ACRONYMS AND ABBREVIATIONS

AELGA	African Emergency Locust/Grasshopper Assistance project, A.I.D. Africa Bureau (AFR/TR/ANR)
AGRHYMET	Agro-Hydro-Meteorology, a CILSS institute, based in Niamey, Niger
AID/W	U.S. Agency for International Development, Washington, DC
A.I.D.	Agency for International Development
APHIS	Animal and Plant Health Inspection Service of U.S. Department of Agriculture -- USDA/APHIS
CFR	U.S. Code of Federal Regulations
ChE	Cholinesterase, an enzyme involved in neural transmission, inhibition of which can indicate pesticide exposure
CIDA	Canadian International Development Agency (=ACDI in French)
CILSS	Comité Inter-Etat de Lutte Contre la Secheresse dans le Sahel (Permanent Committee to Counteract Drought in the Sahel)
CITES	Convention on the Importation and Transport of Endangered Species
CMDT	Compagnie Malienne de Dévéloppement des Textiles (parastatal company devoted to cotton production)
COPR	Centre for Overseas Pest Research, then Overseas Development and Natural Resources Institute (ODNRI), and since 1990, simply NRI (U.K.).
CPS	national Crop Protection Service (SPV in Mali)
DGIS	Directoraat Generaal Internationale Samenwerking (Directorate General for International Assistance, The Netherlands), which funds DFPV
DFPV	Département de Formation en Protection des Végétaux (Plant Protection Training Center), at CILSS-AGRHYMET Center, Niamey, Niger
EA	Environmental Assessment
EPA	U.S. Environmental Protection Agency
FAC	Fonds d'Aide et Coopération Française (French Assistance and Cooperation Fund)
FAO	Food and Agriculture Organization (United Nations)
FEWS	Famine Early Warning System, of A.I.D.
GRM	Government of the Republic of Mali
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit (German Technical Cooperation Agency)
ha	hectare (1 ha = 2.47 acres)
IER	Institut d'Economie Rurale, Mali's national agricultural research system

IFAD	International Fund for Agricultural Development
IIBC	International Institute of Biological Control (formerly Commonwealth Inst. Biol. Contr.), U.K.
IITA	International Institute of Tropical Agriculture (Nigeria), with the Biological Control Program (IITA-BCP), based at Cotonou, Benin
INSAH	Institut du Sahel, a CILSS institute, based in Bamako, Mali
INRSP	Institut National de Recherche en Santé Publique, Bamako
IPM	integrated pest management
ITCZ	Intertropical Convergence Zone (equivalent to Front Intertropical [FIT] in French, or Intertropical Front [ITF])
L/G, l/g	shorthand for: locust and grasshopper
LMR	Limite Maximum de Residus (residue tolerance level), established by WHO/FAO Development Committee for pesticide residues on food crops
mg/kg	milligram per kilogram body weight
NGO	non-governmental organization
NRI	Natural Resources Institute (formerly ODNRI, q.v.), U.K.
OCLALAV	Organisation Commune de Lutte Antiacridienne et de Lutte Antiaviaire, Dakar, Senegal
ODA	Overseas Development Administration, U.K.
ODIK	Opération de Développement Intégré du Kaarta (Mali)
ODIPAC	Operation de Developpement Integré des Produits Arachidiers et Céréaliers (Mali)
ODNRI	Overseas Development Natural Resources Institute (in 1990 renamed Natural Resources Institute), United Kingdom.
ODR	Opération de Développement Rural (Mali)
OICMA	Organisation Internationale contre le Criquet Migrateur Africain (now defunct)
OPSR	Opération Protection des Semances et Recoltes (predecessor organization to SPV)
PEA	*Programmatic Environmental Assessment for Locust and Grasshopper Control in Africa/Asia* (TAMS, 1989). See Sect. 2.0, 2.2 herein.
ppm	parts per million concentration
PRIFAS	Programme de Recherche Interdisciplinaire Français sur les Acridiens du Sahel. French grasshopper/locust research center in Montpellier, France. Operate the "Acridologie Operationelle" and "Ecoforce Internationale".
RAMSAR	Relating to an international convention on designation of wetlands as biological reserves

REDSO	Regional Economic Development Support Office (REDSO/WCA for Western and Coastal Africa)
SAP	Sytème d'Alerte Precoce, an early warning system regarding food security needs in the Sahel
SEA	Supplemental Environmental Assessment
SECAMA	Secours Catholique Malien (an NGO active in training of farmers)
SMPC	Société Malienne des Produits Chimiques (pesticide formulation and repackaging plant in Bamako, Mali)
SPV	Service National en Protection des Végétaux (National Crop Protection Service, Mali). Referred to as CPS herein.
UCTR/PV	Unité de Coordination Technique Régionale en Protection des Végétaux (Regional Technical Coordination Unit for Crop Protection), CILSS-INSAH, Bamako, Mali
UNDP	United Nations Development Program
USAID/Mali	A.I.D. Mission to Mali, located in Bamako (USAID/Bamako also used)
USDA	U.S. Department of Agriculture

PREFACE

This report, termed a supplemental environmental assessment (SEA) for the USAID/Mali locust and grasshopper control program, provides an overview of the Mali situation in this matter, reviews technical options, and makes recommendations for action for future operations in response to environmental concerns. This SEA fulfills the requirement under A.I.D. Environmental Procedures to address details specific to Mali, with a view to possible assistance from the USAID. It is a supplement to the Programmatic Environmental Assessment (PEA) (TAMS, 1989) and builds on the PEA to provide a complete picture of the assessment that has been performed.

An interdisciplinary team composed four Malian specialists, and counterparts from AID/AFR staff, jointly produced the first drafts of this report. The team interacted with staff of A.I.D./Bamako, and with sources in the government of the Republic of Mali (GRM), regional institutions (INSAH), and private enterprise (SMPC, Ciba-Geigy). The members of the team are given in Appendix A. Persons interviewed in Mali also are listed in Appendix A.

This document was reviewed by AID/W, USAID/Mali and by the Government of Mali. The SEA should be regarded as a dynamic document, meant for active use in the planning of USAID-funded grasshopper and/or locust control interventions. It should be reviewed and updated by amendment, as necessary, to give an accurate description of the program supported, and an assessment of the likely environmental consequences of an assistance program. Future program development is contingent on the actual needs for grasshopper or locust control and on a decision by A.I.D. to provide assistance.

ACKNOWLEDGEMENTS

We wish to especially thank Mamadou Fofana, Coordinator of Locust/Grasshopper Programs, the Grasshopper Action Group (GAG), for USAID/Mali. Mr. Fofana greatly facilitated the development of this SEA by assembling the Mali writing team, making contacts, arranging meetings, researching information, contributing written material, editing, and overseeing the production of the final copy and its translation into French. Mr. Madiou Yattara, USAID/Mali/GAG, patiently and competently entered and re-worked numerous drafts of the various authors, and assisted in essential aspects of the assembly of the final document. We thank Tracy Atwood, Supervisory Agricultural Development Officer, USAID/Mali, for his encouragement and active interest in seeing this SEA provide the foundation for a new phase in strengthening crop protection as an integral part of agricultural development in Mali. Mission Director Dennis Brennan also showed understanding and support for the process which producing this SEA has involved.

Ms. Patricia Peckham, SUNY, Purchase, NY, and Dr. Jon Cooper, are acknowledged for permission to use the maps compiled by Ms. Peckham on pesticide use and protected resources in Mali. Alexander Kremer, agricultural economist with the Mali Millet Pest Control Project, permitted us to use his figure, "Decision Tree for Sponsors of Crop Protection Activities."

1.0 EXECUTIVE SUMMARY

This Supplemental Environmental Assessment (SEA) complements the *Programmatic Environmental Assessment (PEA) for Locust and Grasshopper Control in Africa and Asia*. It provides details specific to Mali on the country situation, biology of the organisms, program operations and options regarding locust and grasshopper control interventions, and identifies reasonably foreseeable significant effects these operations may have on the environment and on people. The Supplemental Environmental Assessment, being an integral part of the PEA, is needed for pesticide-related assistance to be given by the U.S.A.I.D. The information given in the SEA is intended for use by USAID/Mali and the Mali Crop Protection Service (CPS). Additional information should be added as appropriate, because this is meant to be used as dynamic reference to help design sound programs.

In response to the desert locust and grasshopper upsurges of 1985 - 1990, the U.S. Agency for International Development in Mali (USAID/Mali) provided over U.S. $5.0 million in bilateral funds alone, for technical assistance, equipment, training, pesticides and aircraft. About $500,000 more were provided through the FAO and central project sources (Africa Emergency Locust Grasshopper Assistance Project, 698-01517) for assistance with surveillance and control activities. **Since 1989, the emphasis in U.S. support to the Government of the Republic of Mali has been specifically on building the national capacity to deal with the grasshopper and desert locust problems in the long-term.**

The Malian CPS, formed in 1988, is headquartered in Bamako, with eight phytosanitary bases and five observation posts distributed throughout the country. The staff consists of about 150 persons, of whom some 60 are technically trained to one extent or another. In the longer view, the CPS will not be able to maintain the nearly exclusive focus on grasshoppers it has had since being created. Any efforts to strengthen the crop protection service require that its capability to deal with the full range of pest problems be enhanced. Linkages to sister agencies such as the national agricultural research station, IER, need to be strengthened.

TRAINING

As relates to grasshopper and locust control, and crop protection in general, **the level of expertise in the GRM and CPS has been greatly strengthened over the past five years.** However, there is a shortage of expertise in critical environmental areas such as ecotoxicology, environmental monitoring, and pesticide management, especially disposal of obsolete pesticides and pesticide containers. Pest management expertise should also be strengthened in specific areas, including locust and grasshopper survey and monitoring, crop loss assessment, and insect pathology. Mali would benefit from technical assistance and training opportunities from AID/W, USDA and USEPA through USAID/Bamako, as needed, in order to strengthen development of national capacity to combat the grasshopper/locust and other crop pest problems over the long-term.

Much benefit would be derived from **strengthening extension teaching efforts**, particularly with regard to reaching the field agents' needs, and through them the illiterate peasant, with the goal of **strengthening village brigades.** The village brigade training activities, while at the present stage appropriately concentrating on safe pesticide use, should also attempt to

reinforce alternative techniques of control, particularly along the lines of the IPM trials recently carried out in the OHV area.

The present system of pesticide applicator training and education should continue and be improved to ensure proper and safe pesticide application. Each applicator crew should be independent in ability to handle any cases of poisoning that occur, including administration of antidote and removal from exposure of any worker showing symptoms (see section 7.1). The Ministry of Health and CPS should work cooperatively on the delivery of training in the safe use of pesticides, the recognition of symptoms of pesticide poisonings, and the treatment of pesticide poisonings. This collaboration would occur during control campaigns, so as to raise the awareness of the populace, and to provide for surveillance before and after.

CROP LOSS ASSESSMENT AND SURVEILLANCE

Crop loss assessment and economic thresholds are important concepts in IPM. Research should be continued in Mali to arrive at better decision-making tools for locust or grasshopper control. Strong collaboration between CPS and other divisions of the Ministry of Rural Development and Environment should be fostered in order to improve the available data. INSAH, with its Pest Management Coordinating and Food Security units, could be a strong partner in these efforts.

The social and economic value of l/g programs for the people and the government of Mali remains relatively unquestioned. It would be useful to measure the scope and the necessity of such programs as an element of any strategies and alternatives which might be developed.

Requests for assistance must be based on objectively verifiable data. A.I.D. should respond to requests for assistance only when reliable data on the anticipated level of damage is available. The emphasis should be on prevention and early season intervention. Late season treatments, especially, should be minimized to the extent possible. Post-harvest spraying does not at this time appear to be justified. Likewise, aerial operations require a particularly careful analysis of need. Moreover, CPS should prepare annual work plans describing intended campaign operations and how the SEA recommendations will be carried out.

The use of greenness maps and their further development as a tool for surveillance need to be encouraged.

LEGISLATION

Mali has limited environmental protection legislation, but significant changes are underway. Recently, a law on toxic wastes was passed and draft legislation has been proposed on pesticides, crop protection and prevention and control of hazardous wastes. Improved pesticide legislation is under development. When pesticide and toxic substances legislation is enacted, it is probable that GRM could benefit from technical assistance in connection with implementation. USAID could support the provision of appropriate outside expertise to assist the GRM to become self-sufficient in pesticide regulation.

Fragile ecological areas, particularly aquatic ecosystems, need to be protected from pesticides. Buffer zones of at least 2 - 2.5 kilometers surrounding areas to be protected should be established. Regulations should be developed which formally restrict or forbid the treatment of locusts or

grasshoppers in the Niger Inland Delta and in the national parks. A map showing distribution of the principal acridid species, other major insect pests, and granivorous birds, in relation to the reserves and other areas to be protected in Mali, would be a very useful contribution to the environmental protection of Mali with respect to decision-making for treatments against acridid and other pests.

CONTROL ALTERNATIVES AND IPM

CPS should be encouraged to prepare its annual work (campaign) plans describing the details of intended operations. Ideally, the work plan would indicate how the recommendations in this SEA will be implemented.

Excellent potential exists for progress in developing programs of research and development on alternative approaches to managing grasshoppers and other pests, based on progress achieved in recent years by the GRM in cooperation with NRI, FAO-UNDP, USAID, and others.

Through the Institute d'Economie Rurale (IER) and CPS, and in collaboration as appropriate with other agencies, donors, ICRISAT, etc., USAID could support an applied research program on methods of biological control, traditional control and integrated pest management. This research should include, for example (Sect. 5.5): the use of neem, Azadirachta indica, for the protection of subsistence crops in the Sahel; the pursuit of trials with biological control agents of acridid species; evaluation of agronomic and cultural techniques as elements of an IPM approach.

CPS should greatly increase its training of farmers and others in techniques to minimize infestations, working with others in identifying, and elaborating through applied research, appropriate alternative techniques. Greater farmer involvement, especially early in the development of grasshoppers, can prevent the need for greater pesticide intervention later. This can be especially true for cultural controls, alternate crops and inter-cropping. For example, weeding of crops and margins of fields appears to be effective in reducing numbers and damage of grasshoppers.

PESTICIDE MANAGEMENT

The major stocks of obsolete pesticides in Mali consist of at least 80,000 liters of dieldrin, 25,000 liters of lindane 16% ULV, 12,000 liters of fenitrothion ULV, 400 liters and 575 kg of BHC, 630 liters of parathion ULV, and various amounts of miscellaneous pesticides. Nearly all of these are at least 15 years old.

Proper disposal of these chemicals is essential but should not be undertaken until a best technology for the local situation is determined. USAID/Bamako may want to consider supporting a feasibility study. A plan developed in Niger for removal and disposal of 73,000 l of dieldrin, should be carefully considered by Mali because the situation in Mali is analogous to that in Niger (Sect. 6.4). Attempts could be made to put this issue onto the agenda of the inter-ministerial committee on the environment (Sect. 3.2.3).

Pesticide management systems and infrastructure in Mali are improving, but need continuing attention. USAID could provide support and technical assistance for training in logistics and operations management and help construct and improve structures for pesticide storage.

MONITORING

Exposure to pesticides and the risk of unexpected occurrence of acute chemical poisoning is most likely to occur with handlers, applicators, pilots, and pesticide formulation plant workers. Monitoring applicator exposure through cholinesterase levels has preventive value. In any case, it is essential to conduct baseline testing in order to correctly interpret the results of cholinesterase tests. Testing of the general population, by contrast, is of much less value since exposure of the general population is expected to be minimal and random cholinesterase levels measured in a human population are too variable to be of very much value.

In areas of extensive pesticide use, environmental samples analyzed for residues would be a valuable basis for assessing exposure. Therefore, residue-based exposure assessment should be used in the process of refining and designing of future pesticide activities. Residue evaluation should be a collaborative work of CPS, Malian Society of Plant Protection and the National Institute of Public Health Research's Toxicology Laboratory. The technical capacity in Mali for residue analyses should be reinforced to provide future services in residue analyses and other related services.

Monitoring environmental impacts of pesticides, including side effects on non-target and beneficial organisms, is a valuable means of detecting their possible misuse. Such activities should be integrated as part and parcel of any pesticide use program. The results of these monitoring activities could be used in the planning and implementation phases of locust and grasshopper control programs to minimize environmentally damaging operations.

2.0 PURPOSE AND PROCEDURES

With the latest major upsurge of desert locusts in Africa beginning late 1986 and lasting into 1989, and extensive grasshopper outbreaks throughout the Sahel from 1985 through 1989, the U.S. government was urgently called upon to respond with technical assistance and materials. In 1987, the Administrator of the U.S. Agency for International Development declared an emergency waiver of the agency's environmental procedures governing the provision of pesticides in connection with development assistance. A requirement associated with the waiver was that a major "Programmatic Environmental Assessment" (PEA) be produced. Such a PEA was developed, and was accepted by AID/W in mid-1989 (TAMS 1989). The waiver permitted the Asia/Near East and Africa Bureaus and the missions in the affected countries to provide assistance for the procurement and use of pesticides for locust/grasshopper control without full compliance with the Agency's environmental procedures until the waiver expired on August 15, 1989. Any future A.I.D. assistance for the procurement and use of pesticides must comply with the Agency's environmental procedures. The basis for these procedures is detailed in the PEA. Compliance would entail the preparation of a country-specific "Supplemental Environmental Assessment" (SEA) which would address the 38 recommendations made in the PEA in the context of country-specific conditions.

USAID/Mali contributed in a major way to the emergency response to the simultaneous grasshopper and locust upsurges in 1985\86 to 1989, with about five million U.S. dollars invested, more than any other bilateral or multilateral donor. Nearly half of this amount was spent in 1988 on aerial and ground application of pesticides, vehicles, spare parts and maintenance, fuel; technical assistance for monitoring and logistics; and pesticide safety equipment. When the Africa Emergency Locust/Grasshopper Project (AELGA) was authorized in 1987, USAID/Mali bought in for technical assistance for greenness maps to aid in survey for locusts; grasshopper surveys, particularly egg-pod surveys; evaluation and monitoring of environmental impact and exposure to pesticides; training in pesticide safety; research into pesticide efficacy and biological control approaches; and provision of approved pesticides. The mission has formulated a long-term plan for building institutional capacity in Mali to deal with this problem area, to allow earlier, more cost-effective and environmentally-sound interventions.

Given the cyclical nature of locust outbreaks, and the chronic but fluctuating populations of grasshoppers, locust and grasshopper control campaigns are likely to continue indefinitely in Mali and elsewhere. This may be especially true in Mali, reported to offer the "best" range of targets for grasshopper and locust research (Popov 1989). The abundance of locusts and grasshoppers is likely to periodically lead to requests for A.I.D. technical assistance, aerial application services, commodities, equipment and/or insecticides. It is expected that for the near term, most of these requests will be related to the use of chemicals for control operations, either directly or indirectly. For A.I.D. to fill such requests the Environmental Procedures in Regulation 16 (22 CFR 216) have to be followed (see Section 3.1). This document reports the steps that have been, and need to be, taken to fulfill the requirements of those Procedures in order to provide assistance to Mali.

2.1 Procedure To Determine Scope

A.I.D. Environmental Procedures (22 CFR 216.3(a)(4), commonly referred to as "Regulation 16", describes the scoping process to be used in

identifying the major issues to be addressed in an Environmental Assessment. The rationale and approach for the country-specific Supplemental Environmental Assessment [SEA] are outlined in cables 89 State 258416 (12 Aug. 1989) and 89 State 275775 (28 Aug. 1989). The proposed scope, timing and format of the Mali SEA were described by cable 89 Bamako 7068, approved by AID/W in 89 State 378673.

Critical elements of process to determine scope include 1) determination of the scope and significance of issues to be analyzed as they relate to the proposed action, 2) identification of issues that are not significant or that have been covered by earlier assessments, and elimination of them from detailed analysis, 3) timing of the analysis, 4) format, 5) decision-making schedule, and 6) description of how the analysis will be conducted and what disciplines and expertise will participate (representatives of host governments, public and private institutions, A.I.D. staff and contractors should be considered). Since this assessment is supplementary to the PEA, the process of determining scope for this part of the assessment was much abbreviated.

2.2 Previous Assessments

The major previous assessment is the *Programmatic Environmental Assessment for Locust and Grasshopper Control in Africa/Asia* (TAMS, 1989) (PEA). That PEA covered grasshopper and locust control operations in Africa and the Near East. The Environmental Procedures provide for the preparation of what are generically termed "Subsequent Environmental Assessments" on major individual actions when subsequent activities may have significant environmental impacts on specific countries and where those impacts were not adequately addressed in the programmatic environmental assessment (22 CFR 216.6(d)). Because of the breadth of the PEA, impacts in individual countries, such as Mali, could not be addressed. An initial determination has been made that supplementary environmental assessments, as described in 22 CFR 216.6(d), will be necessary for all countries with significant locust and/or grasshopper control programs in order for any pesticide-related assistance to be provided. It is expected that Mali might be one such country, because it has been a major recipient of aid for locust and grasshopper control in the past.

This document is designed to fulfill the need for a "subsequent environmental assessment" for Mali. It is a supplement to the PEA and relies heavily on the PEA to provide a complete picture of the assessment that has been performed. In other words, the PEA should be considered an integral part of this document. Other assessments that have been performed include:

(1) *The Africa Emergency Locust/Grasshopper Assistance Mid-term Evaluation* (with country-specific case studies for Chad, Mali, Niger, Mauritania, and Cape Verde) (Appleby, Settle & Showler, 1989);
(2) *Draft Environmental Assessment of the Tunisia Locust Control Campaign* (Potter et al, 1988);
(3) *Environmental Assessment of the Morocco Locust Control Project* (Rutanen-Whaley, 1988);
(4) *Environmental Assessment Update - Morocco Locust Control Project Paper Supplement (Annex B)* (Loken, 1988);
(5) *Provisional Report on Pesticide Management in Francophone West Africa* (Alomenu, 1989, Report to the FAO Conference at Accra, Ghana).

(6) *Supplemental Environmental Assessment of the Senegal Locust/ Grasshopper Control Program* (Stanley, Cavin, Engler, and Powers 1990).

These documents have been used freely in performing this assessment and often are relied on without citation. Other relevant documents are cited in the text when data from them are used to support the assessment.

2.3 Analysis and Document Preparation

Background papers and related document materials were prepared and assembled by four GRM technical specialists: Dr. Boubacar Cissé (Ministry of Public Health), Dr. Yocouba O. Doumbia (Ministry of Agriculture, IER), Lassana Sylvestre Diarra, and Moussa Keita (Ministry of Agriculture, CPS).

This team was then joined by an AID/W TDY team composed of Drs. Walter I. Knausenberger and Ronald A. Stanley, who during about two weeks analyzed all relevant documents, and assembled the information into a comprehensive working draft. The team also interviewed individuals at USAID/Bamako, in the Government of the Republic of Mali, some regional institutions, NGOs, and private enterprise. Dr. Knausenberger also assisted in the scoping prior to beginning of the analysis and writing, and, during several follow-up visits, in completing the SEA following formal review of the draft in AID/W. Lists of the team members and of their contacts are presented in Appendix A.

3.0 ENVIRONMENTAL REGULATIONS

3.1 A.I.D. Environmental Procedures

It is A.I.D. policy to ensure that environmental consequences of A.I.D.-financed activities are identified and considered by A.I.D. and host governments prior to final decisions about those activities. Furthermore, such environmental consequences shall be weighed heavily in the outcome of decisions and shall be used to design environmental safeguards and methods of mitigation. This document covers both the specifics of how environmental consequences were weighed in making the decisions about possible continued support of pesticide use and the commitments to safeguards and mitigation for any future control programs. Section 2.0 above summarizes the approach and rationale, and the PEA (TAMS 1989) provides essential background documentation.

3.2 Environmental Regulations in Mali

In Mali, environmental protection constitutes one of the major concerns of political and administrative authorities. The problems associated with safeguarding the environment and the ecosystem are addressed by the government mainly through the Ministries of (a) Agriculture, (b) Environment and Animal Husbandry and (c) Public Health and Social Affairs.

Mali has limited environmental protection legislation, but significant changes are underway. Recently, a law on toxic wastes was passed, and draft legislation has been proposed on (a) pesticide importation, use and distribution (see section 3.3), (b) crop protection, and prevention and control of industrial wastes. As yet, there are no procedures equivalent to the National Environmental Policy Act (NEPA) or A.I.D.'s Regulation 16 regarding environmental documentation which would influence decision-making in locust and grasshopper control campaigns. Thus, A.I.D. Environmental Procedures are likely to be controlling for the present because they are more comprehensive and applicable to A.I.D. exigencies.

3.2.1. Pesticides

To combat the ravages of locusts and grasshoppers, a number of insecticides have been used. In 1988, according to a CPS report (S.P.V. 1988), more than 2 million liters (liquid) and a ton (dry) of pesticides were used in the country in all agriculture and human and animal health applications.

Pesticides used in agriculture were previously under the management of the Operation for Seed and Harvest Protection [OPSR]. This body undoubtedly performed its mandate under the decree of January 26, 1926 regulating the sale and use of poisonous substances in French West Africa (j.o. no. 1120 of 6 March 1926), and no. 84/MAES which prohibit the sale within the Sudanese Republic (Mali), of certain products used in crop protection (j.o.no.19 of 15 April 1959).

At present, no legislation concerning plant health protection has been enacted in Mali. The National Plant Protection Service (SNPV, now referred to as SPV), the creation of which goes back to 1987, is currently working to provide this type of legislation for the country. On December 7-8, 1989, in Bamako, a technical meeting was held on plant health protection legislation and regulation in Mali. This meeting, organized by the SPV brought together

those services involved from the different Ministry divisions and two FAO consultants, was able to develop language for rules and regulations pertaining to plant protection as well as the standardization and control of pesticides in Mali.

Draft legislation on the Approval and Control of Pesticides is expected to be passed during legislative session by 1991. Its purpose is to create the national policy with regard to pesticides, notably, control of importation, marketing, labelling, use, storage of pesticides, as well as their fabrication, reconditioning, reformulation and transportation. Disposal of obsolete pesticide stocks is also to be addressed. The definition of "pesticide" is broad enough to include biological agents, such as fungal pesticides based on *Beauveria*, and biorational products such as neem or pheromones.

A Committee on Pesticides, created by the Ministry of Agriculture, is to be charged with putting in place the process by which a pesticide will be permitted to be marketed in Mali. Enforcement authority will be vested in the CPS, *in collaboration with the Service de la Repression des Fraudes.*

In the past, pesticides were selected based on tests and efficacy trials held by either the agronomic research units of the Institut d'Economie Rurale (IER), by the Inter-African Organization for African Migratory Locust Control (OICMA), by Interstate Organization for Locust/Grasshopper and Bird Control (OCLALAV), or based on results obtained in neighboring countries, adhering to the FAO Plant Phytosanitary Products norms.

At the December 1989 meeting mentioned above, proposed Plant Protection and Quarantine legislation came under discussion, likewise to be considered by the GRM legislature by 1991. The main elements of this law concern the establishment of a system of surveillance, monitoring and notification for *exotic and indigenous pest organisms, as well as prevention* and control of importation and exports of pest organisms. The law as now drafted will prescribe the conditions of introduction, multiplication and use of animals, plants and microorganisms to control pest organisms.

Currently, the CPS, while waiting for the adoption of legislation and regulations for plant health protection, uses the FAO Code of Conduct (1986) for agricultural pesticide usage in Mali. Also, it is important to emphasize that some donors, such as USAID, concerned with protecting the environment, seek to ensure that the donor countries' legislation on pesticide use is taken into account. The pesticides used in locust/grasshopper control in Mali are registered by the U.S. Environmental Protection Agency (EPA) and are accepted by USAID within the framework of the assistance it provides.

3.2.2 Toxic Wastes

Hazardous and toxic wastes represent a significant area of interest to the GRM. Mali hosted the first Pan-African Conference on Environment and Sustainable Development in Africa (January 1991), where a major focus was upon a convention regulating the import and movement of hazardous wastes in Africa. In 1989, a toxic wastes law was voted in by the Republic of Mali's National Assembly (Loi no. 89-61/AN-RM, 13.9.89, *Portant Repression de l'Importation, du Transit des Dechets Toxiques*). It restricts the importation and transit of toxic wastes in Mali. This law forbids the <u>importation</u> of any toxic wastes.

A decree of application of this law (Decret No. 90-355/P-RM) also extends government regulatory control to the importation of useful products that are toxic, such as pesticides and drugs (Halter 1990). The law apparently does not consider toxic materials that are not imported, but are produced domestically. In terms of public health, it is more important to address these latter areas than to simply focus on impacts of wastes (Halter 1989b). Also, it is worth considering whether wastes to be recycled for productive uses should be excluded from a ban (e.g., pesticide reformulation and barrel reconditioning).

3.2.3 Environment and Natural Resources

The GRM proposes to review all its laws, decrees and regulations pertaining to the environment. This ambitious undertaking reflects the high priority that the government places on improved environmental management (Halter 1989a). The focus of this activity is broadened beyond agriculture, livestock and natural resources conservation, to include quality of life in urban centers with respect to sanitation and industrial pollution. An inter-ministerial committee on the environment has been established and is actively tackling these issues (Halter 1990).

With respect to natural resources management and sustaining biodiversity, the need for a new legal framework has been recognized. Mali presently has no conservation strategy (Warshall 1989), although the national anti-desertification plan (Plan National de la Lutte Contre la Secheresse - PNLCD) acts as an umbrella for many natural resources management projects. Many sectors, among them rural development, irrigated agriculture, and crop protection, have not incorporated a conservation strategy. This SEA may be regarded as representing a step in that direction for the CPS.

Several international and African accords have been signed by the GRM regarding the conservation and management of wildlife. These include the African Convention for the Conservation and Management of Wildlife and Its Habitat, the African Convention on the Conservation of Nature and Natural Resources, and the Convention Concerning Protection of the World's Cultural and Natural Heritage. Also, as mentioned earlier, GRM subscribes to the FAO Code of Conduct on the Use of Pesticides. These agreements indicate a commitment to protection of natural resources. Unfortunately, GRM has not signed the CITES Convention, but it has set aside RAMSAR sites (IUCN 1989). From the standpoint of international interest, as well as protecting the economic productivity of natural systems, the Niger Inland Delta contains ideal candidate locations for RAMSAR sites (see Section 8.3).

Mali has a number of other standards and guidelines with potential relevance to environmental quality. These include the Wildlife Management Code, the Forestry Code, the Fisheries Code, and the Fire Code. In general, these do not act as restrictions on detrimental activities because they are outdated and few resources are devoted to enforcement. All are under review (Warshall 1989); any provisions relevant to grasshopper or locust control will be incorporated into the program when enacted.

This SEA is consistent with the GRM commitment to protection of the natural environment. It adopts programmatic conditions designed to limit pesticide use and it designates areas for protection from pesticide use.

4.0 COUNTRY AND SITUATION DESCRIPTION

4.1 Description of the Physical Environment and Meteorology

Mali is a landlocked country of approximately 1.24 million square kilometers, comprising 4.2% of the total area of Africa. The country, half of which is arid land, lies between 10° and 20° North latitude and 12° West and 4.15° East longitude. Mali is bordered on the north by Mauritania and the Algerian Sahara, on the east and southeast by Niger, on the south by Burkina-Faso, Ivory Coast and Guinea, and on the west by Senegal (Figure 1).

4.1.1 Topography

A description can be found in a work produced on the Agroclimatology of Mali (Sivakumar et al., 1984). The country is characterized by flat relief, slightly hilly where low plateaus emerge or basins occur. The plateaus, remnants of the ancient continental shelf of West Africa, have been covered by nearly horizontal primary deposits consisting normally of sandstone, sometimes with iron. These low-altitude plateaus (300-400 meters) descend toward the north until reaching the Niger basin, and also toward the south. The Adrar des Iforas, located in northeast Mali, is a massive shelf (500-800 meters high), which gives an irregular appearance due to blocks of rock and granite piled up and dispersed in secondary chains. The mountain chain is separated from the Niger Valley by a series of basins covered with sand and fossilized valleys. In the southwest, the Guinean mountains of Fouta-Djallon stretch out into a plateau descending toward the northeast up to the vicinity of Koulikoro in Mali.

The sandstone that overhangs the surrounding plain is characteristic of the country. Among the mountain ranges, there are four which are the most important: the Manding Plateau (maximum altitude - 794 meters) in the west, the Sikasso Mountain (820 meters) in the south, the Dogon Plateau (777 meters) in the southwest) and the adjacent Hombori Mountain (1150 meters).

North of the 15th parallel, the relief of the arid region is fashioned by the wind. The expanses of sand are sprinkled with rather high dunes, aligned in the direction of the prevailing wind (east - northeast).

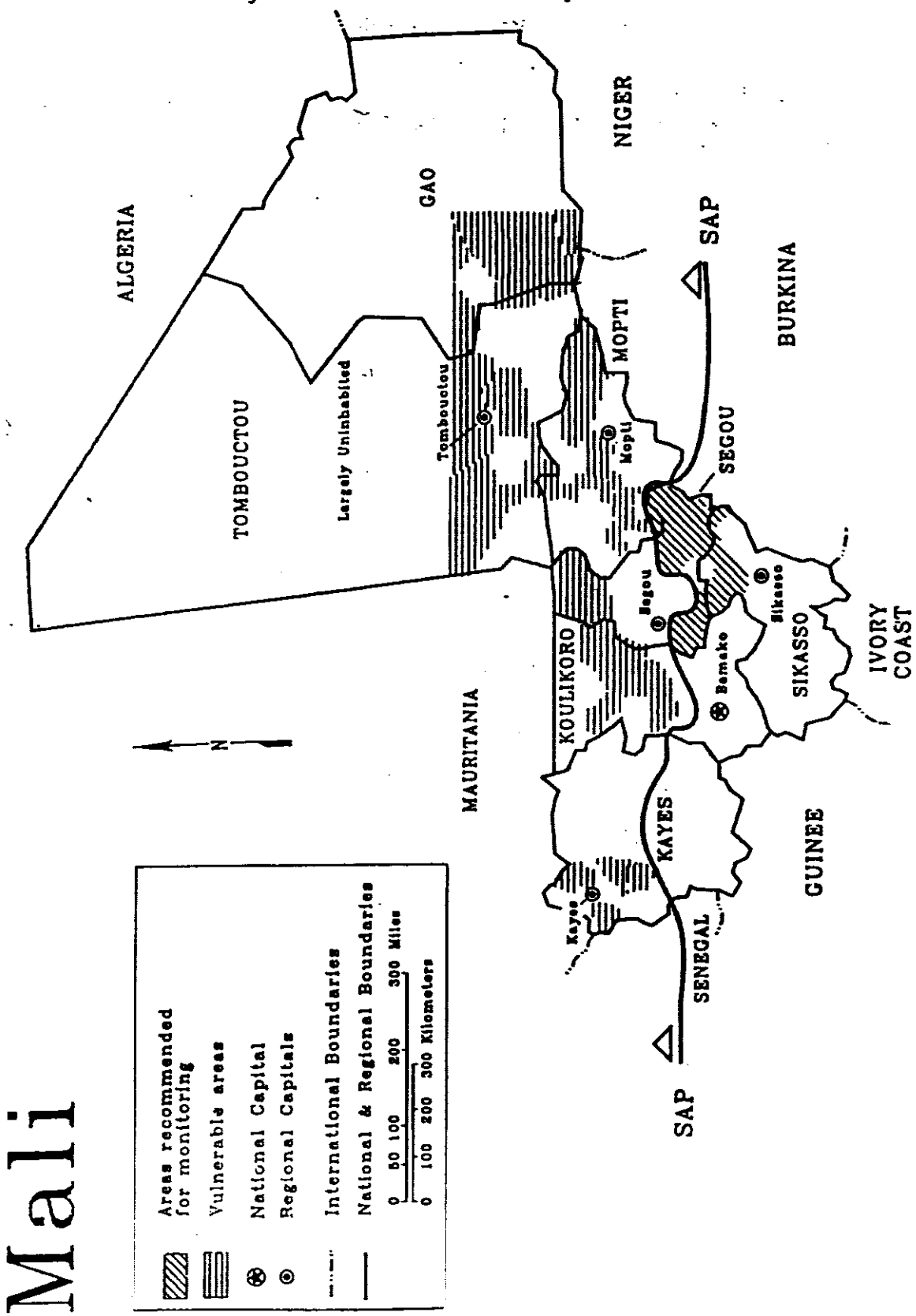
4.1.2 The Soil

Sufficiently detailed soil studies have been conducted in Mali to characterize the general soil types and taxonomy throughout the country (TAMS 1983, Map C-5). Biotic zones in Mali are determined by a combination of soil types and climate (rainfall and temperature). The major soil types that influence biotic zones are:

- recent alluvial soils characteristic of the central Niger Inland Delta;

- the Irma and Iboudan series characteristic of the eastern Gourma region;

Figure 1. Map of Mali, showing the key regions and cities, with representative indications of areas of vulnerability from the point of view of food security in 1988. The SAP line indicates the limit north of which the Système d'Alerte Precoce operates. Source: FEWS 1988.



- Socle with complex basement characteristic in part of Sudanian woodland dominated by Isoberlinia in the south.

Other soil types and/or underlying geological formations present in Mali include Permian dolerites, gray sandstone, Precambrian Toun shales, Jurassic continental intercalary, Cambrian Nara argillites, Quaternary dunes, and Upper Tertiary continental terminal. These soil types can be relevant to agricultural productivity and local vegetation types, but natural biotic zones in the rest of Mali are dominated by climate rather than soils.

4.1.3 Some Climatic Characteristics

Mali is an intertropical country, with marked Sahelo-Sudanian characteristics. Temperatures are generally high, with a yearly average between 26 - 30 degrees centigrade. The months of April and May are the warmest, and December and January the coolest.

Rainfall, seasons and wind: The year is divided into seasons by the movement of the Intertropical convergence zone (ITCZ), which brings the rains.

In Mali, the length of the dry season varies from 9 months in the north to 5 to 6 months in the south, and the rainy season is from April to October in the south and from July to September in the north with marked inter-seasons corresponding to months which are neither humid nor dry. During the dry season, the country is subject to the passage of continental trade winds called "Harmattan". This wind comes from the northeast and has a drying effect that accentuates the effect of the high temperatures throughout the country in April/May. During a locust invasion, the action of the Harmattan is a determining factor in whether the swarms go to the north or the south. The Harmattan and the monsoon airflows blow from opposite sides towards the ITCZ -- at ground surface they meet at the intertropical front (ITF). The movement of swarms is determined by their position in relation to the ITF. In autumn and winter the northward migration is influenced by the Mediterranean depressions.

The principal factor about the rainy season is the passage of the moisture-laden monsoons on an oceanic track, which, after crossing the equator, takes a direction southwest to northeast. The annual rainfall varies from less than 100 mm at the latitude of Tessalit to 1400 mm to the south of Sikasso. The relative humidity is 80% in August south of Sikasso and 40% at Tessalit during the same period. Evapotranspiration varies from less than 1700 mm/year to the south of Sikasso to more than 2500 mm/year at Tessalit. August is the month with the most rain.

4.2 Agroecological Zones of Mali

The agrogeological zones established by the Inventory of Land Resources Project, known as PIRT (TAMS 1983), are the result of a combining ecological zoning with three essential notions which contribute to the use of resources for crop production, namely: humidity, soil temperature and the length of the agricultural season. There are at least five agroecological zones, from north to south: the Saharan, the Sahelian (northern and southern), the

Sudanian (northern and southern), and the northern Guinean. The inland delta of the Niger is a special zone in the center of the country which straddles the Sudanian and Sahelian zones (TAMS, 1983; Traore 1980) (Figures 2 and 6).

Below is a brief description of these zones from an agricultural perspective. Further environmental characteristics are covered in Sect. 8.1.

4.2.1 The Saharan Zone

This zone is characterized by very unpredictable, irregular rainfall, usually less than 150 mm. Unlike the rest of the country, there is only a single temperature peak in an annual cycle. Rainfall does not saturate the soil, which can only absorb what little water is not immediately evaporated. Drought is the limiting factor, reinforced by the wind which accentuates evaporation. Run-off is an important aspect, and most the vegetation is concentrated along wadis and in depressions. As soon as the soil is penetrated by the water, a layer of green vegetation appears (except where edaphic aridity prevails -- e.g., in the Tanezrouft, upper northeast Mali), which temporarily provides nourishment for nomads and animals.

These plants (ephemerals) grow rapidly; as soon as the rain stops, they dry up and disappear, after having dispersed their seeds. Others (geophytes) store reserve water in their underground roots during this short period, in order to survive the adverse conditions to come. Among the plants adapted to this climate are *Cornulaca monocantha*, *Panicum turgidum*, *Stipagrostis pungens*, *S. longiflora*, and *Calligonum comosum*. *Acacia ehrenbergiana* and some rare dwarf bushes are found in depressions such as Tilemsi.

Subterranean water sources are said to be abundant, and located at variable depths. In some cases, they are salty. Surface waters are limited to the Niger River (at the southern limit of the desert), to the oases, to the wadis and a few ponds.

The Saharan zone shelters some wild animals particularly adapted to the climate (gazelles, moufflons, addax, etc.), as well as predators, reptiles, birds and insects -- particularly the desert locust (*Schistocerca gregaria*).

4.2.2 Sahelian Zones

From a climatic point of view, the fundamental feature of these zones is the length of the growing (rainy) season (3 to 4 months from June, July and August-September). Rainfall varies between 200 and 800 mm per year.

Vegetation is dominated by drought-resistant species, but is more uniformly distributed than in the Saharan zone. The vegetative cover is comprised of small dwarf trees, often spiny, with a crown spread like a parasol. The herbaceous carpet, often thin, grows rapidly with the first rains, at the same time that the others become green again. The long dry season forces the plants to have a long dormant period, often marked by falling leaves, except for *Faidherbia (=Acacia) albida*, which has the opposite cycle. While seasonal rain-fed (dry) farming is practiced in the southern parts, which receive more than 350 mm annual rainfall, the Sahel is especially

suitable for herding. Perennial grasslands exist in the south, but in the north, annual prairies which include such grasses as *Schoenefeltia, Cenchrus* spp. and *Aristida* spp. predominate. The herbaceous carpet is formed especially of perennial grain species which have an underground stump that survives during the long dry season.

The important bushy stratum is dominated by *Boscia senegalensis and Guiera senegalensis*. The woody species include many spiny plants: *Acacia raddiana, Acacia ehrenbergiana, Acacia senegal* (gum arabic), *Acacia seyal, Acacia nilotica*, numerous Combretaceae, among which is *Combretum glutinosum*. It is appropriate also to cite *Commiphora africana, Pterocarpus lucens, Adansonia digitata*, which are trees adapted to occasional deficits of rainfall.

The Sahel is a land of moving pastures. Animal breeding is the only lifestyle which assures permanent use of the region due to the movement from one pasture to another. The increase in both human and animal populations represents a risk for this fragile environment.

4.2.3. Sudanian Zone

This zone is characterized by a dry season of 7 to 8 months and a rainfall of between 750 and 1250 mm. The rainy season is longer than in the Sahel. The vegetation is woody savannah. From the south to the north, it degenerates progressively to a less woody savannah. The ground cover is made up of hardy grain species and annual grain species. When dry, the ground cover is a yellow straw color, and readily combustible for the bush fires that frequently accompany the harmattan.

Among the hardy grain species are *Andropogon gayanus, Hyparrhenia dissoluta, Cymbopogon giganteus, Ctenium newtonii, Loudetia simplex*, and among the annual grain species, *Andropogon pseudapricus, Pennisetum pedicellatum, Eragrotis tremula, and Ctenium elegans*.

Among the woody species in the Sudan zone, if *Combretum* and spiny species are still numerous, certain species which demand more water are disappearing. Besides *Butyrospermum parkii*, which "appears where the Sudan begins", there are *Parkia biglobosa, Faidherbia (=Acacia) albida, Borassus aethiopum, Tamarindus indica, Adansonia digitata, and Bombax costatum*

The Sudanian zone is an active zone for both subsistence crops and commercial crops (cotton, peanuts) and for animal husbandry, especially for sedentary herding, although migration is occurring from south to north.

4.2.4 North Guinean Zone

This zone corresponds to a mosaic of wooded savannahs and thin forests, both regularly subject to bush fires. The vegetation includes many perennial species. The North-Guinean Zone is marked by cereal culture and commercial crops (cotton), fruits, tubers. There is traditional sedentary animal husbandry that makes use of trypanosome-tolerant breeds which are smaller than Sahelian varieties.

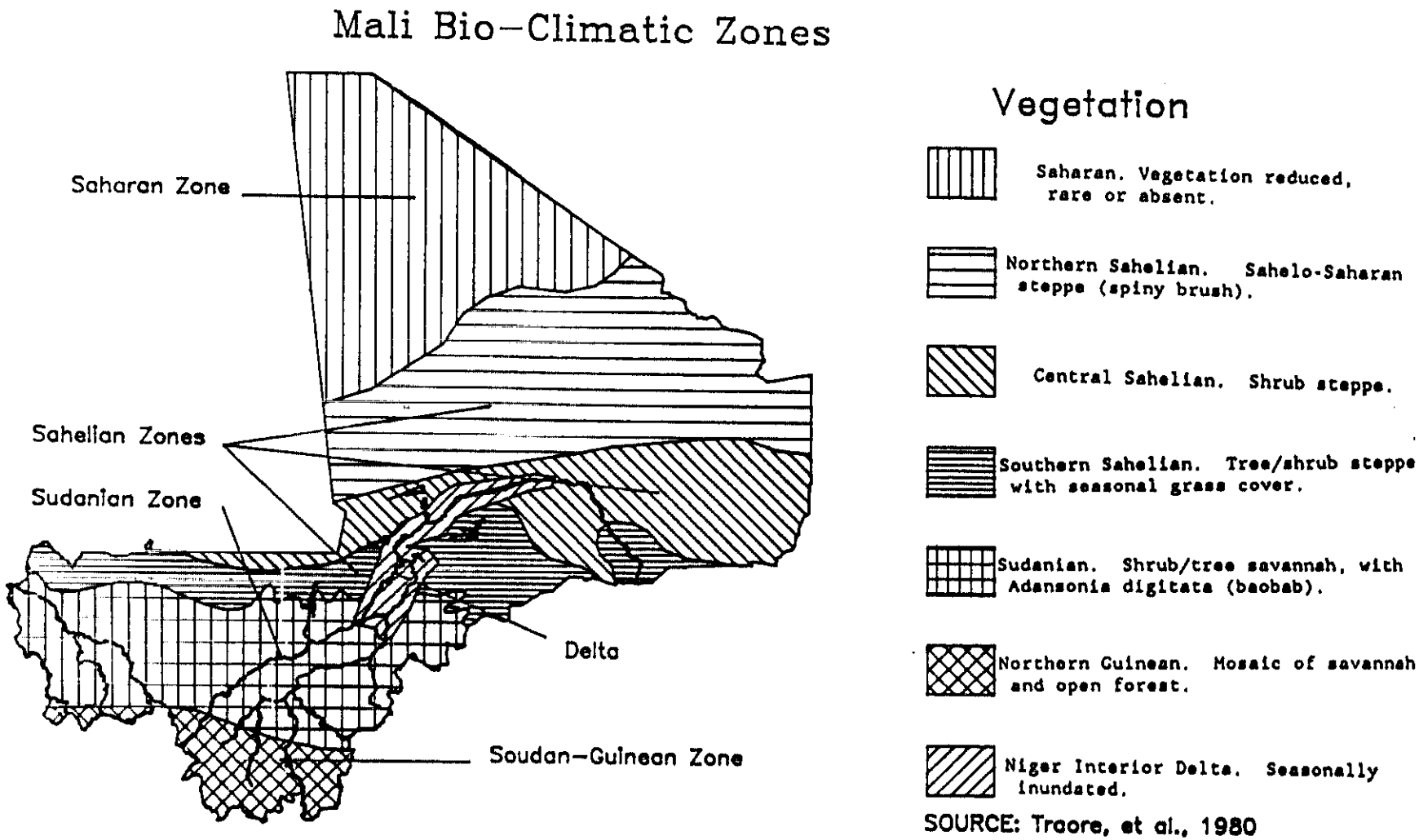


Figure 2. Bio-climatic/Agroecological Zones Mali (after Traore 1980).

4.2.5 The Inland Delta of the Niger River

Located in the heart of the Sahel, the Niger delta allows the presence of species normally found further south, or those adapted to wetter environments. Large areas are submerged for varying lengths of time, permitting the culture of rice, for example, as well as the traditional grain crops, millet and sorghum.

The vegetation of the inland delta has great floral originality. The different types of vegetation of the plains which are seasonally inundated depend on the duration of their submersion:

- in the submerged plains, less than three months per year, the dominant vegetative type is the group *Vetiveria nigritana* often associated with *Andropogon gayanus*;

- for areas submerged between three and six months, the ground cover is characterized by *Echinochloa stagnina* and *Oryza longistaminata* (wild rice);

- basins submerged more than 6 months comprise the most original vegetation of the delta: the "bourgouttière" (floating rice).

4.3 Agricultural Resources Threatened by Locusts and Grasshoppers: Loss Assessment

Food crops not only are threatened by climatic hazards (drought and low rainfall), but every year grasshoppers -- and locusts of one species or another -- cause a significant loss in food crop harvests (Tables 1 and 2). Over the last decade, Mali has been affected by locust/grasshopper invasions, especially Senegalese grasshoppers and Desert locusts. The consequences of the damage these insects cause tend to be aggravated by cycles of drought that negate the peasants' efforts. For that reason, the cereals deficit reportedly has grown steadily by this dual action of drought and grasshopper/locust attack. This is the perception on which action to combat the insects is based. Improved means of measuring the impact of, and means of dealing with, the problem must be found.

A four-year study on the importance of grasshoppers as crop pests, conducted in the 1970's at the Institute of Agricultural Research in northern Nigeria, has general relevance to the Sahel. The conclusions from this study are summarized as follows (Popov 1990):

a) grasshoppers are chronic pests of agricultural crops, and are well known as such by the peasant farmers. When shown a collection of different species they usually have no hesitation in pointing out the principal species of concern to themselves;
b) a score or so of species typically are involved, each with their own biological, behavioral and ecological characteristics, but often occurring as mixed populations dominated by one or a few species;
c) the overall level of crop loss (based on the 1965-69 period) is not

high -- on the order of 5 to 6 percent, but locally it can be high, leading to considerable hardship for the rural community concerned;
d) there is considerable annual variation from year to year, associated mainly with the pattern of distribution, the quantity and timing of the rains and the resulting natural vegetation.

In addition to locusts and grasshoppers, other pests increasingly have been the target of control efforts. These include notably head mining caterpillars (esp. Heliocheilus albipunctella), stem boring caterpillars (*Cotiesta (=Acigona)*, various beetles -- esp. Meloidae (also inaccurately referred by some as Cantharidae -- *Psalydollyta* spp.); and Scarabaeidae:Cetoniinae (*Pachnoda* spp.), granivorous birds and rodents. Plant diseases and weeds, notably witch weed (Striga spp.) also enter the picture. Recently, granivorous birds have become a major concern in certain areas where roosting and nesting concentrations have become established, such as around Mopti in the Inner Delta (SPV 1991b).

4.3.1. Agriculture and Animal Husbandry

Agriculture and animal husbandry constitute the dominant economic activities of Mali. Agriculture is the principal occupation of 90 percent of the population. Varieties of millet, sorghum, maize, fonio *(Digitaria exillis)* and peanuts are the main food crops for home consumption, produced by 89 percent of the active population, using traditional methods of production. Rice is the next largest crop, half of which is grown in the Niger central delta. Other rice-producing regions are the Senegal Valley, the Niger valley from Bamako to Segou and from Gao to Ansongo, as well as the Sikasso region in the south.

The best alluvia of the Niger valley are maize-producing, half of the production of which comes from Sikasso, in peanuts and in truck farming (vegetable) crops. Also, fruits are grown, especially mangoes and citrus, to better meet the urban population needs, as well as a small export demand.

Cotton and peanuts, two important commercial crops, are destined for national industries and exportation. Cotton is primarily grown in the Sikasso region, where half the crop is grown; the rest comes from the Segou, Mopti and Koulikoro regions and from the Bamako district. Peanut growing is mainly concentrated in the west, with the regions of Kayes and Koulikoro and the Bamako district producing two-thirds of the harvest. Tea, sugar cane, rice and tobacco have been introduced respectively into the regions of Sikasso, Segou, Koulikoro and the Bamako district. Gum, Juglans cinerea, and kapok [silk-cotton tree, Ceiba spp.] are grown in the Sahelian zone. Ké-Macina, in the Niger central delta with its fertile soils, and Niono, in the Office du Niger area, lend themselves to irrigated industrial crops such as rice, cotton, tea and sugar cane.

In over half the country, the arid environment allows only for itinerant livestock raising, for example, nomadism (Touaregs) and the seasonal movement of livestock (Fulani) (Peuhl, in French) in the Sahel and the Saharan regions. Raising livestock in a fixed location is mainly practiced in Southern Mali.

4.3.2 Crops at Risk

Cereals, notably millet, sorghum, maize and rice, are the crops most attacked by locusts and grasshoppers. Of these crops, millet and maize are most vulnerable. Cotton, peanuts and other food legumes are generally attacked to a lesser degree. A map of the main crops at risk, not including pasture and savanah rangeland, is given in Figure 3.

However, it must be pointed out that while locust and grasshopper attacks on crops most often show themselves as major harvest losses, pastures and rangelands, consisting in part of wild grasses, are not spared. Losses to crops and pastures have been recorded throughout the dry tropics since antiquity. Each year grasshopper damage, mainly by Oedaleus senegalensis, but often involving a complex of species, is noted on crops and pastures, yet the losses are incompletely evaluated. Research on crop loss assessment has recently greatly increased, mainly as related to millet (see Sect. 4.3.3).

Much of Mali between the 12th and 17th parallels is predominately pasture land. It is a preferred habitat for O. sénégalensis and other graminivorous grasshopper species. Both perennial and short-lived annual vegetation is present. Recent (1986-89) control efforts have concentrated on these rangelands, which were considered to be reservoirs for infestation that would move to cropland. This effort has been justified based on the protection of the cropland that is presumed to accrue from treatment of adjacent bush fallow and rangeland. Yet, this linkage has not been conclusively established. Indeed, the current consensus, reflected in the 1990 FAO Grasshopper Campaign Planning meeting in Rome, is that treatments aimed mainly at grasshopper population reduction rather than crop protection, including post-harvest treatment of grasshopper adults, should no longer be supported. The population reduction strategy had led to ever-increasing levels of pesticide use between 1985 to 1989, yet evidence of the impact of end-of-season treatments on next season's grasshopper populations is lacking.

On the other hand, the value of pasture biomass lost may itself justify control efforts. Research on crop loss assessment should also include pastures (G. Cavin 1990, pers. commun.). Jago (1991, pers. commun.) indicates that expanses of grasslands in northwest Mali were extensively stripped of their biomass by grasshoppers in 1988 and 1989, but that the Peuhls were able to move their grazing cattle to areas less affected. Two points can be made in this context: (1) given the mobile nomadic nature of Sahelian pastoralism, there is no evidence that pasture losses are seriously detrimental to animal production (Popov 1991, pers. commun.); and (2) as yet, no way exists of substantially reducing grasshopper numbers in grasslands, except by large-scale chemical control. This is a subject which deserves closer socio-economic scrutiny.

In Mali, as elsewhere in the Sahel, very few exact evaluations of locust/grasshopper damage are available. The greatest grasshopper damage, by O. senegalensis in particular, takes place at the seedling stage of millet and often necessitates numerous replantings (Popov 1978). The milky grain stage of cereals constitutes the second period of vulnerability to grasshopper damage.

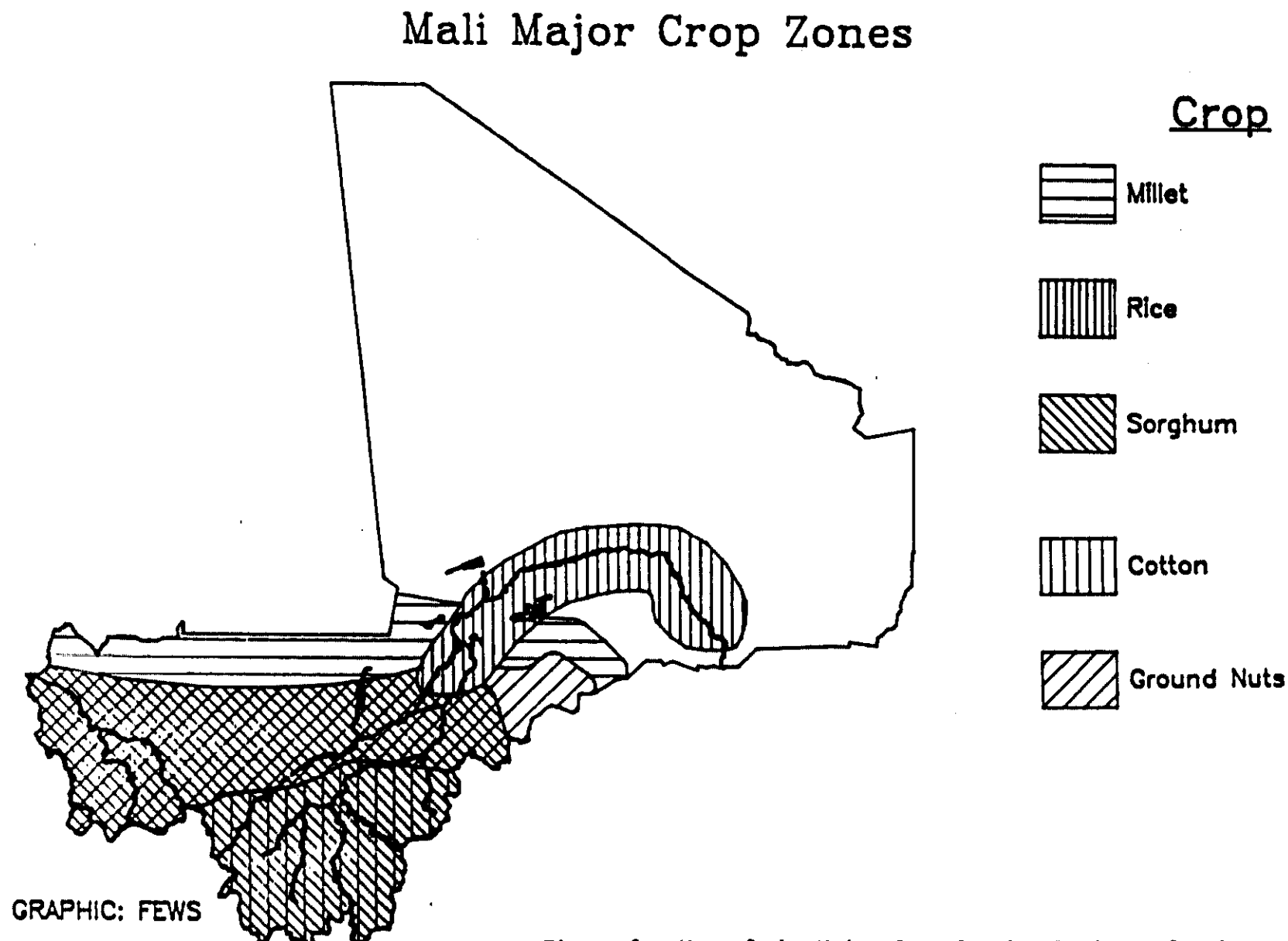


Figure 3. Map of the Major Crop Growing Regions of Mali.

4.3.3 Crop loss assessment

Crop loss assessment and economic thresholds are important concepts in IPM. Treatment costs and benefits must be evaluated if rational decisions are to be made. The focus of the following discussion will be on millet, which is the major grain staple crop in the Sahel, and which is attacked by a wide range of pests, while it is often also in a delicate balance with drought. Little quantitative information has been available regarding the relative impact of the pest complex on millet yields. Such information is needed to better judge the need for, efficacy and cost effectiveness of plant protection measures.

The available productivity data per region are widely variable. Compare, for example, millet production in Segou for 1988 with 1989 in Tables 1 and 2. It is unlikely that true productivity varied so greatly. The infestations of locusts or grasshoppers tend to be restricted to certain parts of Mali, notably the area identified as the "millet belt" on Figure 1. Further examples of this regional productivity are discussed below.

Damage done by grasshoppers on rice, millet and other crops in 1982 over a 9,000 ha area of Mali has been estimated at 3 million CFA, about $10,000 (unpublished data from ODNRI). A 23.7 percent reduction in millet and sorghum production after the grasshopper swarming activity was noted throughout Mali in 1985 (Table 3). The same source reports that the percentage of losses in millet and sorghum in the northern and western regions of Mali varied from 10 to 100 percent (Table 4).

In 1989, severe grasshopper damage was registered on natural vegetation and crops. The severity of the attacks varied from one sector to another, starting with the second ten-day period of September. According to a CPS report (SPV 1990), millet was the most affected crop, with damage varying from 60 to 100 percent in the sectors of Koro-east, Douentza-north, Nioro of the Sahel and Diema. In the sectors of Dilly-Mourdiah and North Segou, damage varied from 20 to 60 percent. For the whole invasion area situated between the 14th and 16th parallels, production losses were estimated at about 37 percent.

The 1990/91 campaign was less intense that of 1989/90, but major centers of infestation occurred in regions surrounding Mopti, Mourdiah, and Ségou, many of same areas as the previous year (Bouaichi 1990, SPV 1991).

In an approach used by the CPS currently to determine the value of its treatment campaign, infestation levels are assessed at the period when the crops approach the critical heading stage when the grains are at the most vulnerable stage, the milky grain stage. This occurs during the months of September to November, depending upon the cropping region. In 1989, treated hectarage was estimated at 722,492 ha (of 1,500,000 ha estimated to have been infested). Given the following assumptions:

- the average yield of millet and sorghum is ca. 1,000 kg/ha,
- if no treatment occurred, loss would be total (unrealistic),
- the price of grain is 70 FCFA per kg,

then the following calculation can be given:

1000 kg/ha x 722,492 ha x 70 FCFA/kg = 5,060,000,000 FCFA

or: $U.S. 194,000,000 at an exchange rate of 260 FCFA/$.

In other words, by such simplistic calculations as above, one would conclude that nearly $200 million worth of crops were saved by the interventions of the CPS during the 1989 season. However, this approach does not hold up to scrutiny, mainly due to three factors: (a) little or no account is taken of the level of infestation, by which species, or combination of species; (b) little information exists to quantify the relationship between level of infestations and crop loss, and (c) little verification of the efficacy of treatment is done. Also, as yet, no standardized and quantified methodology exists for crop loss assessment in millet and sorghum, and little of no quantified statistics on pest losses is gathered by the national agricultural production assessment processes (P. Bartel, FEWS, and M. Keita, CPS, pers. commun. 1991)

The uncertainty and variability in regional productivity data is a serious flaw. This is true not only because of the poor crop production data but also because of poor data relating crop losses to populations of locusts and grasshoppers. An attempt to establish this relationship would be difficult and expensive. Nevertheless, further effort in this area is essential. Much would be gained by closer collaboration between the crop protection service and the food security assessment agencies such as the Famine Early Warning System (FEWS) of USAID, the Système d'Alerte Precoce (SAP), and Diagnostique Permanente (DIAPER) (INSAH-UCTR-PV 1991b).

Despite the regional variability and the uncertainty in the data, national level estimation is possible. The best estimates of rate of loss vary from 1.5% (FAO "low" estimate in the PEA, comparable to the Level 0 in this SEA) [1] to a high of 20% (Appleby et al 1989). This suggests that moderate level losses to the Mali millet crop are likely to be:

- 999,900 metric tons (Table 1) x 60 000 FCFA per ton x 1.5%, equalling 0.9 billion CFA ($3.5 million U.S. at 260 FCFA/1 $U.S.)

At the rate of loss estimated for a Level III infestation, total losses in Mali alone might be:

- 999 900 metric tons x 60 000 CFA per ton x 20%, equalling 12 billion CFA ($46 million U.S. at 260 FCFA/1 $U.S.)

Levels I and II infestation would presumably be intermediate (perhaps $20 and $30 million, respectively). If these estimates are correct, investments by GRM and donors of $6 million at Level I and $10 million at Level III would seem well justified. In addition to national aggregate losses, some

---

[1] See Section 5.4.2, on the infestation levels

consideration needs to be given to the social and economic costs of grain distribution when losses to individual farmers or villages may be close to 100%. Even if the country as a whole has more than ample grain supplies, as it did in 1989/90, some areas may be devastated. The costs of grain transport over a long distance may be more prohibitively expensive than the locust/grasshopper control program. Timeliness of delivery may also be a constraint. Palatability of imported grain in view of generally conservative tastes is another consideration.

In addition to being used to guide generic decisions about the value of interventions, crop loss assessment has the potential for guiding operations. However, given the lack of timely data on production or even planted area in Mali, control efforts based solely on these data are not practicable at this time. In this regard, data in Mali are of limited use. Production statistics at the cercle level are commonly available the year following the production season. These data obviously cannot be used to guide monthly decisions about the logistics of control operations.

Considering this shortcoming and the weakness in the range of production data cited above, a study of the effectiveness of control operations is needed and important. It would be valuable to improve the quality of crop reporting data, especially as it is related to grasshopper or locust infestations. In this regard, collaboration between CPS and other divisions of the Ministry of Agriculture, for example, the rural extension services and the regional statistics bureaus, might be especially valuable. This SEA strongly urges that such collaboration be fostered in order to improve the available data. It is recognized that fairly close collaboration already exists between the ODR extension officers and the CPS field personnel (see Sect 5.1).

4.3.4 Simulation modeling

Another predictive tool that could be useful for building improved decision-making tools is simulation modeling. A.I.D./W and others are supporting research in this area. The object is to improve our understanding of the relationship between grasshopper numbers and economic loss, utilizing both field data and model analyses. Determining the economic benefits of treatment is a difficult task, due to the many interactions between the environment, the crop, pests, and control operations. A preliminary simulation model (GHLSIM version 1.0) has been developed based on the population dynamics of the Senegalese grasshopper (Coop et al. 1989, Coop and Croft 1991). This model was constructed to provide descriptions of grasshopper and crop interactions, and provide a means of analyzing treatment campaigns, but it has not been fully field-validated. It was designed as a decision-support system, with features such as menus, database entry, and graphic output of results.

While it is not yet ready for real-time predictive use, GHLSIM was used for post-campaign analysis of aerial treatment to 128,000 ha of millet with malathion 96 ULV in central and eastern Chad in 1987. Published economic threshold were used to calibrate the model for the analysis. Treatment costs averaged $ 7.36 per ha and estimated benefits of treatment averaged $19.36 per

ha, for a benefit-cost ratio of 2.6 The estimated benefits of the treatments in reducing end-of-season egg-laying by grasshoppers[2] increased the average benefit-cost ratio estimate to 3.8. However, problems with low yields and late treatment resulted in local benefit-cost ratios of less than 1.0 in several of the regions. A model behavior analysis indicated that optimal timing would have been 5 to 10 days earlier than the actual treatment dates.

During the 1990 growing season in Mali, research supporting field validation and improvements in functional components was carried out and will be pursued in 1991 and beyond in connection with crop loss assessment research initiated by USAID in Senegal, Gambia and Chad (INSAH-UCTR-PV 1991b). Plans are underway to redesign the GHLSIM model for determination of economic injury levels and action thresholds for several additional grasshopper species. For each species, damage rates, development time, feeding preferences, natural mortality, and insecticide effects will be estimated and represented. In addition, the environmental risk component of the GHLSIM database will be updated.

A difficulty with simulation modelling is that it must be based on field data to have any validity. Thus, it will tend to suffer from all the uncertainties discussed above until better field data are available. However, simulation can be a useful adjunct to field data, and in the long-term, modelling research might have some relevance to conditions in Mali, as well as other locations that have Senegalese grasshopper populations. Other organizations which have recently initiated crop loss assessment research on millet in the Sahel include GTZ in Niger (began in 1988), NRI in Mali (1985 on), and CIDA (in Niger and Burkina Faso) (INSAH-UCTR-PV 1991b).

Table 1: Actual Cereal Production During the 1988-89 Agricultural Season.
Source: EAC, DNSI/DNA/PADEM, OSCE

REGIONS	Millet	Sorghum	Rice	Maize	Fonio	TOTAL
KAYES	11333	131562	-	36867	3655	183417
KOULIKORO	163015	172014	46	42959	2111	380145
SIKASSO	155827	150514	8639	112575	3457	431012
SEGOU	323434	157591	13438	22118	10961	527542
MOPTI	315609	25358	70578	-	-	411545
TOMBOUCTOU	30610	33851	15683	-	-	80144
GAO	73	1539	25273	-	-	26885
SECTEUR MODERNE			154140			154140
TOTAL	999901	672429	287797	214519	20184	2194830

[2] An unproven assumption: see Sect. 4.3.2 above

Table 2: Forecast of Cereal Harvest for 1989/90. Source: EAC, DNSI/DNA.

REGIONS	Millet	Sorghum	Rice	Maize	Fonio	TOTAL
KAYES	17570	178920	-	39080	2780	238350
KOULIKORO	185840	121360	150	61000	5680	374030
SIKASSO	69850	209210	11140	112580	3150	405930
SEGOU	255510	161180	3630	15260	5480	441066
MOPTI	302980	9290	89630	-	-	401900
TOMBOUCTOU	30000	34000	16000	-	-	80000
GAO	80	1710	32770	-	-	34560
SECTEUR MODERNE			175550			175550
TOTAL	861830		328870	227920	17090	2151380

Table 3: Revised assessment regarding the production of millet and sorghum following the grasshopper outbreaks of 1985 (MASI, 1986).

Regions	Estimates before the outbreaks t	Revised 1985 estimate t	Estimates of losses due to grasshoppers %
Kayes	45,753	36,603	20
Yélimané	13,433	8,732	35
Nara	21,645	14,070	35
Nioro	28,627	22,330	22
Diéma	17,036	14,992	12
Niafunké	8,325	6,244	25
	134,819	102,971	Avr. = 25

Initial estimate: 134,819
Revised estimate: 102,971

Reduction in yield: 31,848 = 23.7%

Table 4: Evaluation of losses in millet and sorghum due to grasshoppers, and an overview of the egg pods in soil November 1985 (MASI 1986).

Regions-localities	Crop Losses due due to grasshoppers millet (percent)	sorghum	Oothecae in the soil/m²	Remarks
Région Yélimané	50	25		treated
Yélimané-20 km W Nioro				
1. Kodie	30	10	0	treated
2. Kremiss	r	25	0	untreated
3. Kouroungourou	r	20	8	untreated
4. Bougoudré	100	10	0	untreated
5. Koriga	r	10	4	untreated
6. 5 km E.Koriga	non cultivated		0	untreated
7. 10 km E.Koriga	non cultivated		0	untreated
8. 15 km E.Koriga	non cultivated		0	untreated
20 km W Nioro-25 km W Ballé				
1. Palal	30	20	4	untreated
2. 10 km NE Palal	100	-	6	untreated
3. Nioro du Sahel	35	10	5	untreated
4. 10 km E. Nioro	40	10	0	untreated
5. 10 km SE Touroug	15	-	-	untreated
6. Gourca	10	-	0	untreated
7. Madina-Fofara	35	10	0	untreated
25 km SW Ballé-15 km NW Dilly				
1. 15 km SW Ballé	35	-	0	untreated
2. Vouainca	non cultivated		0	untreated
3. Ballé, Est. gén.	45	20	-	untreated
4. Tarandela	40	20	5	treated
15 km NW Dilly-Mourdiah				
1. 15 km NW Dilly	non cultivated		0	treated
2. 12 km NW Dilly	20	20	-	treated
3. Amdalay	60	10	-	treated
4. Dilly	80	10	0	treated
5. 10 km E Dilly	60	10	0	treated
6. Goumbou	35	-	0	treated
7. 10 km SW Goumbou	65	-	0	treated
Mourdiah				
1. Experimental field	90	10	23	treated
2. Experimental field	90	-	12	treated

(r) = Harvest (récolte) (-) = Evaluation not possible

4.4. Locust and Grasshopper Characteristics

4.4.1 Distribution and Movements

4.4.1.1 Locusts

Three species of locusts occur in Mali, and all three have breeding and outbreak areas partly or wholly there: the desert locust, Schistocerca gregaria; the African migratory locust, Locusta migratoria migratorioïdes, and the tree locust, Anacridium melanorhodon.

Desert locust. Two distinct distribution patterns occur, based on whether recession or plague conditions are prevailing:

1. **Recession breeding areas.** The principal areas where breeding and gregarization occur in Mali during recessions is in the extreme northwestern part of the country, in the mountainous zones of the Adrar des Ifoghas, the Timetrine, the Tamesna and the Azaouad and Tilemsi Valleys (TAT). Recession breeding is usually at its peak during September to November, but may occasionally start earlier and continue later. In its remission stage, this locust's movements are limited to those valley formed by the wadis, where they can be found as long as conditions favorable to survival are found. Most locust habitats are in wadis and depressions where flood waters accumulate. Farther south in northern Sahel south of about 17 degrees north, breeding may occur during the monsoon -- July to September, but it is usually diffuse and at low density. The new generation produced here will usually move to the TAT, where a second generation may be produced (Figure 4).

2. **Plague breeding areas.** During invasion periods, the gregarious individuals move about in swarms between the Sahel (with one or two summer reproductions), the Maghreb, the Middle and Far East (also with one or two winter-spring reproductions). During this period, all the breeding areas operate as long as conditions are favorable for the insect's multiplication. The breeding areas mainly extend in a belt through the northern Sahel. The highest frequency breeding areas are associated with major geomorphological features. The borders of the Mauritanian Adras, Assaba, Affolé, the Dhahr Tichitt-Oualata in Mauritania, extending south to Yelimane-Nioro area in NW Mali, and from there to the lakes of the central Niger delta, and the Gourma, then the Menaka-Azaouak area of eastern Mali, extending N to include the recession breeding areas in TAT (Figure 5).

During plagues, the Desert locust has a heightened range of migration: during the 1988 invasion, swarms were able to cross the Mediterranean and were found in Europe (Italy and Great Britain) and, what is even more impressive, some crossed the Atlantic ocean, reaching the Caribbean islands in October 1988.

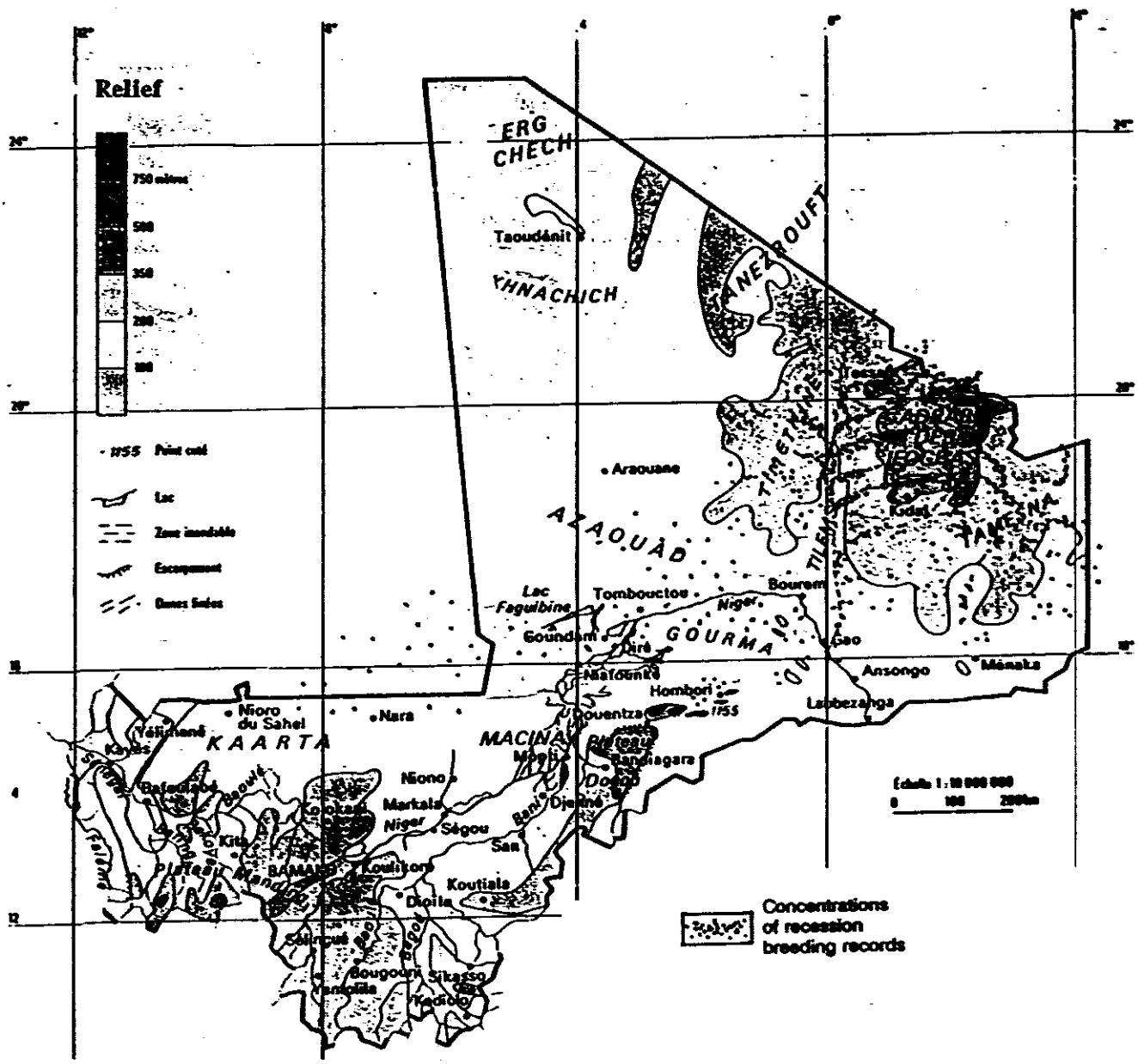


Figure 4. Recession Breeding Areas of the Desert Locust in Mali (base map adapted from Traore et al. 1980). Stippling is only representative of the concentrations of breeding records, and is not meant to be precise (information from G. Popov, 1991).

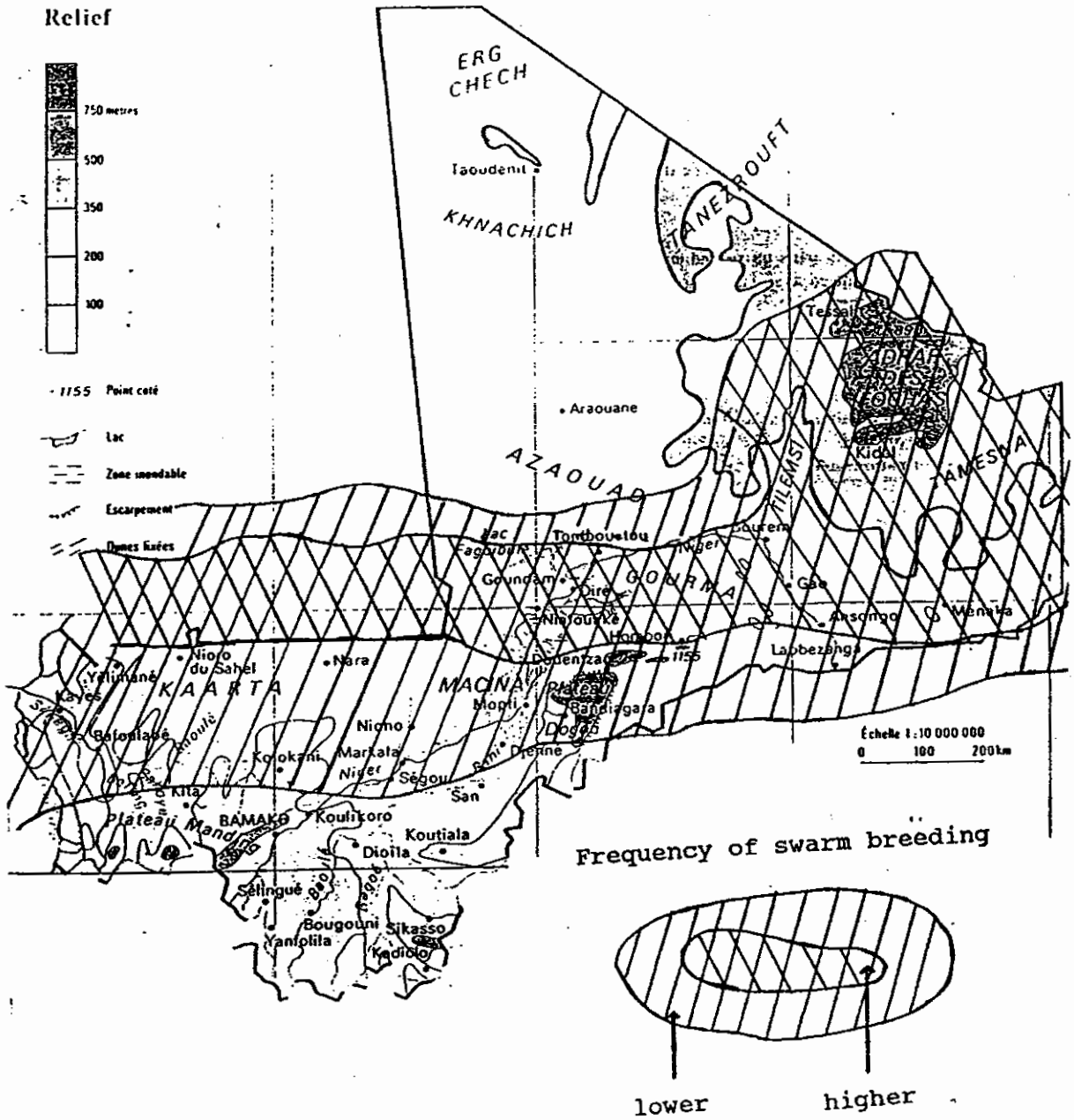


Figure 5. Plague Breeding Areas of the Desert Locust in Mali (base map adapted from Traore et al. 1980). Cross-hatching is only representative of the concentrations of breeding records, and is not meant to be precise (information from G. Popov, 1991).

African migratory locust. In its solitary state, this insect can be found all over the Sahel, but up until now, its principal breeding/outbreak area has been the Niger Interior delta (from Ke-Macina to Timbuktu) in Mali, in addition to the Lake Chad basin. In its solitary state, this insect's movements are limited to this interior delta and the riparian (Sahelian & Sudanian) zones adjacent to it. These movements are governed by the Niger River's flood cycle and the dynamics of the ITCZ. In its gregarious state, swarms of these insects invade the whole of sub-Saharan africa, as noted during the last invasion period, 1928-1941.

Tree locusts. In Mali there are two species of tree locusts Anacridium melanorhodon and A. wernerellum. These locusts feed essentially on leaves of woody plants, and their ability to form swarms is less pronounced than that of the preceding species. These are found in the Sahel and Sahel-Sudanian regions of the territory in the form of small gregarious swarms which are fairly mobile between November and May. *A. melanorhodon* is apparently on the increase since summer 1989 -- there are sizable swarms being sighted in Mali (Bouaichi 1990). One swarm sighted in early February 1991 20 km south of Mourdiah was 1 km long and damage was reported to mangoes from Macina (Popov pers. commun. 1991). However, damage caused by the tree locust is not likely to be major, with the possible exception of in the Sudan to gum acacias.

4.4.1.2 Grasshoppers

The grasshopper fauna of Mali is quite varied but those species which have come to our attention for their economic importance are mainly Oedaleus senegalensis, Kraussaria angulifera, Kraussela amabile, Cataloipus cymbiferus, and Hieroglyphus daganensis. Diabolocatantops axillaris reached major pest status in 1989 and 1990, for the first time. Oedaleus johnstoni causes damage to pastures in the Adrar, and has been repeatedly controlled in past by OCLALAV. Other species are associated with these, though they are of less economic importance: Ornithacris cavroisi, Jagoa gwynni, Cryptocatantops haemorrhoidalis. The latter species are found throughout the Sahelian zone (13th to 16th parallels), where they move about to a limited extent, governed by the range of ecological and climatic conditions that they can tolerate. Hieroglyphus daganensis is an exception because it is occurs in both a short and long-winged form. It can thus extend its range from its normal habitat in swamplands, where it inflicts damage on rice, to a wide range of other agro-ecosystems, including also becoming a pest of maize and millet. Aiolopus simulatrix is sometimes important in the Yelimane and Ansongo areas. This species is associated with clayey riverine habitats, and sorghum crops in recession agriculture sites.

The principal grasshopper pest of recent years, Oedaleus senegalensis (OSE), is a migratory species which swarms over much of the Sahel, and which moves northward and southward with the movement of the ITCZ. Prior to the drought of the late 1960's - early 1970's, this species was not considered particularly abundant, and never a major crop pest. With the return of rainfall to normal in 1974, OSE assumed major importance from Chad to Senegal (Popov 1990). In 1985/86, OSE again was the chief species involved in a major outbreak. Another species, K. amabile, formerly regarded as of little

economic importance, in 1988/89 began to swarm in pastures, and ultimately invaded the crops. It is only now, five years after the beginning of the 1985/86 grasshopper outbreaks, that the numbers of the principal pest species are showing signs of decline (Popov 1990). On the other hand, some, like the tree locust, are apparently on the increase.

Finally, the variegated grasshopper (Zonocerus variegatus) is common farther south, throughout the Sudano-Guinean zone of Mali. Breeding usually occurs in wastelands overgrown with Eupatorium, Solanum, etc. Older nymphs and adults move into crops. This species causes considerable damage to fruit trees, cassava, and truck-farming crops. Damage to citrus and cassava can be particularly serious. Because a high percentage of the individual insects have reduced wings, this species does not move very much, although there can be considerable short-range movement by older nymphs and adults between the source areas in Eupatorium beds in wastelands and the adjacent plantations.

4.4.1.3 Ecological Observations

Thus far, the discussion has considered mainly geographic aspects of distribution in Mali; however, behavioral and ecological characteristics of acridids, and particularly their mobility at certain stages of their development, all affect the faunal composition and the spatial distribution of the populations of grasshoppers (Popov 1989). These factors are clearly of considerable relevance to assessments of the impact of various interventions. Identification of the principal high-frequency danger zones where breeding and outbreaks have occurred should facilitate early detection and reduce pesticide use. For the Desert Locust, the pocket guidebook by Duranton and LeCoq (1990)(No. 6 in the Collection Acridologie Operationelle series distributed by DPFV-CILSS), and a forthcoming FAO publication (expected 1991), an atlas of the breeding areas produced by George Popov, should significantly advance the cause of preventive control.

Several studies have been undertaken on the ecological aspects of distribution, notably by the former Centre for Overseas Pest Control (COPR, NRI) (Steedman 1988) and PRIFAS (note, for example, the "Acridologie Operationelle" series, e.g. LeCoq and Mestre 1988). PRIFAS has produced a functional simulation model of the Senegalese grasshopper, currently in its fourth version (OSE Biomodel 4.0). The biomodel keys grasshopper development to temperature and rainfall, and has apparently represented the pattern of egg-deposition and density fairly accurately. This has been validated indirectly in Mali and Chad, where predictions made by the model at the end of the previous season were found to coincide quite well with the results of egg pod surveys in those two countries during 1989/1990 (PRIFAS 1990). Bouachi (1990) also shows maps which suggest a reasonably good correlation between areas with high densitites of egg pods in the 1989/90 post-harvest survey and the 1990 grasshopper infestations as reflected in the campign operations.

The OSE 4.0 biomodel has been made available on personal computers in several Sahelian crop protection services. It is possible that the model will prove useful in anticipating the risk of damage to crops, particularly newly emerging millet, by guiding the appropriate prepositioning of control materials, and training of farmer brigades in the areas judged most vulnerable

based on the model and egg pod survey results.

However, despite these different attempts to gain knowledge about Sahelian locusts and grasshoppers, the control methods are not very advanced, as many biological aspects of these insects remain unknown (even for those which have been the object of more or less advanced study -- such as the Senegalese grasshopper, Desert and African migratory locusts) and that is precisely what makes locust/grasshopper forecasting difficult. This is why it would be prudent to promote research on locusts and grasshoppers, and their relationship with the environment. Such research would be the first step leading to a rational control effort.

5.0 CONTROL OPERATIONS AND OPTIONS

5.1 The Crop Protection Service and Other National Agencies

In Mali before 1987, the locust/grasshopper control effort was confined to regional organizations (OCLALAV and OICMA) and the OPSR. That year, a considerably strengthened national crop protection service (Service de la Protection des Végétaux, attached to the Ministry of Agriculture) was created (Ordonnance No. 87-04/P-RM, April 1987). The crop protection service (CPS) took over the locust/grasshopper control effort, in light of the reduced, or the cessation of, control efforts by the regional organizations. It also assumed primary responsibility for all plant protection requirements of the country. The FAO, with UNDP funding, has sited a major four-year crop protection strengthening project at the CPS, beginning 1988. USAID/Mali has also been providing significant support to the CPS. A useful overview of the CPS and its partners is given in SPV (1991b), to be published (INSAH 1991a). A brief history, structure and organigram of the SPV are given in Appendix D-6.

The CPS consists, under a recent decree pertaining to the restructuring and reduction in size of the GRM, of 148 positions, about 60 of which are at the technical level requiring specialized training (SPV 1991b). Currently, howwever, further reductions in personnel are being mandated and implemented. In addition to the central service based in Bamako, there are eight phytosanitary bases (field offices) and an additional five "observation posts" (see App. D-6). The CPS collaborates closely with two other major national agricultural development organizations in organizing and providing training to the farmers. These are the ODR (Rural Development Operation), and the DRA (Direction Regionale de l'Agriculture), each with their own ecological zone of focus. The CMDT is a part of the ODR, but is completely autonomous in matters of pest control on cotton. There is only one private organization in Mali devoted to pest control (apparently mainly as an urban pest control operator), the SMDD (Societé Malienne de Désinsectisation et de Dératisation).

Prior to 1988, the National CPS was practically the only entity mounting interventions on large- and medium-scale infestations. However, the relative role of the CPS is diminishing, thanks to the increasingly important contributions of the village brigades and the NGO's present in the zones affected. SECAMA, the Stromme Foundation and the Association des Eglises Norvegiennes are the main NGO's involved in intervention campaigns and training of villagers.

5.1.1 Operations Plan

The locust/grasshopper control effort is based on a work plan called a "campaign plan" where different actions are recorded and programmed with a view to really successful operations. In Mali, well before the start of each campaign, a proposed campaign plan is prepared by the CPS and submitted to the government and to donors, partners in Mali's development. In this plan, those

means which are available or need to be researched in the areas of pesticides and equipment are expressed (Illustrative tables are presented in Appendix D).

The campaign plan lists treatment objectives, the main species of locusts targeted for action, and need in the areas of:

- training (plant protection agents, rural development operations agents, and peasants);
- methods of treatment (products and equipment);
- logistics (aircraft, vehicles, two-way radio equipment, motor fuels, etc.).

Additional areas should be added in the future, for example: egg pod survey, early warning and surveillance; pesticide management; operations monitoring, environmental monitoring; applied research activities.

5.1.2 Reporting Systems

The entire Sahelian and Sudano-Sahelian belt is under direct surveillance by survey teams of the CPS. This is because it is these regions where the major pests of economic significance occur. Since 1985, at least 15 survey teams have been deployed during the various campaigns (SPV 1991). One of the major tasks of these teams has been the post-season assessment of egg pod deposition by grasshoppers, to provide an indication of its density and bearing on the likely severity and localization of the next season's outbreak.

Reporting comprises several steps:

- Information collection by plant protection survey-staff, the ODR agents, the peasants, or simply travelers. The quality of this information will therefore depend on each of the above-named sources and will therefore require verification by specialized teams so as to have those elements necessary for coherent decision making. The information received is recorded on forms to facilitate assessment of the situation at a given moment, which assessments are made available not only on a regional level (the bases) but also on the central level at Bamako.

- Information transmission. Presently in Mali, all possible means of transmission are used to pass on locust/grasshopper information: travelers, nomads, telephone, the administration; the security forces' communications systems, radios and others. The plant protection services headquarters is in contact with its different bases and mobile survey units via two-way radio equipment.

5.1.3 Surveillance and Forecasting

In Mali, the main elements of locust/grasshopper surveillance and forecasting essentially involve having current information about the:

- distribution of threatening species throughout the country;
- evolution of conditions which could provoke the swarming or movement of these species, which presupposes good knowledge of their biology;

- significance and growth stage of agricultural crops endangered by these species;
- availability of human and material means to use in effective control (material means include products, treatment equipment, logistics, laboratory, etc.)

While present efforts in Mali are far from negligible, a great deal must still be done to improve locust/grasshopper surveillance and forecasting. Indeed, considering the large size of the region affected by the locust/grasshopper problem, the resources currently available are clearly insufficient:

- There is a serious lack of qualified and experienced personnel for survey and analysis. However, an effort is underway to train new surveyors to replace those formerly attached to OICMA and OCLALAV most of whom have reached retirement age.

- Survey and laboratory equipment is nearly totally lacking, which automatically limits all planned advanced research in any area of plant protection.

- in light of the further reduction in personnel taking place, experienced surveyors let go should be given priority when and if subsequent employment opportunities occur on a part-time or seasonal basis.

These examples show the current limits on the surveillance system for locust/grasshopper control efforts in Mali.

Certainly opportunities exist for involving the affected human population as a whole in a decentralized system of surveillance. One such approach is being currently developed through the village and farmer brigade training thrust. Certain incentives might also be invoked to encourage reporting form isolated areas. This SEA recommends the pursuit of alternative means of obtaining needed information, in which, for example. trained village brigades would increasingly be involved.

5.1.4 Role of Greenness Maps in Surveillance

Seasonal vegetation index ("greenness") maps first appeared during the 1988 campaign, financed by USAID, during the invasion of the Desert locust (USGS-EDC 1990). Use of these maps allowed the CPS to orient the survey teams in the field, towards areas which were shown to be greening up, and thus a potential source of build-up of acridids. The results obtained with this operational system were extraordinary for ground control. All at once, the savings realized in pesticides and mechanisms allowed the CPS to reorient its control philosophy by focussing it essentially on ground interventions by augmenting the field teams, who now go out armed with the minimum needed for treatment, due to increased likelihood of successful detection. Thus these maps henceforth should be part of the surveillance methods adopted by the CPS.

Their high cost when first introduced ($58,000 per season - 18 sets of

maps - for each of two contiguous countries) was a disadvantage. Operations would be handicapped were donors to stop financial backing for them. However, once the maps became available through AGRHYMET/CILSS (beginning 1990), costs became more affordable (approx. $150 per map for the first map, and $ 40 for each additional one). The time delay in delivery of the maps has been a concern, but has tended to improve, such that the maps are in the hands of the users within 10 days or less. This could be improved by the use of electronic means of map data transmission, but has not yet been implemented. Further refinement and field validation of spectral sensitivity of the imagery still is needed.

5.1.5 Decision Framework for Action

The information collected and verified by the survey teams is transmitted to the plant protection bases upon which they are based. After examination and comparison with other information which may come from other sources, they are then transmitted to the plant protection service headquarters where a synthesis is made to determine the situation on a national level. The regularity of these evaluations is a function of: (1) the significance and the movement of the pest and, (2) the interest that the event generates among the country's policy makers (daily, weekly or monthly).

Based on the preceding information and taking into account difficulties in communication during the campaigns (difficulties in moving around, frequent breakdowns in two-way radio equipment, limited radio equipment for supplying all teams, and a lack of qualified repair technicians), the CPS is trying to start up a decentralized decision-making mechanism regarding action to be taken in the field. This mechanism, which was the standard OCLALAV approach for controlling gregarizing populations of the Desert locust, has been adapted by the CPS, and implemented starting during a recent campaign (1989/90) in the Adrar. It is comprised of the following three decision-making centers:

a. Field Survey team: equipped with light-weight gear and a small amount of product in order to reach small infested areas that do not require a major treatment team. At this stage, the decision is made by the surveyor.

b. Plant health protection base: has good logistics for land intervention which allow for operations on areas that vary from 100 to 3,000 ha in the best time frame. Thus, the base chief can decide to treat in all cases of infestation of this scale.

c. CPS headquarters: when the infestations go a good deal beyond the means of a base, the decision on reinforcements for action methods is decided at CPS headquarters; headquarters can decide to reallocate materials from another base, or from central warehouses, or to request outside help.

These decisions are subjective because they are based on information which is not as yet readily determined: size of infested areas and density of the insect population. Besides these two criteria, other aspects ought to be

examined, such as extent of threatened crops, the crops stage of development, the product available, etc., in order to establish the right intervention threshold.

In summary, it appears that the current state of decision-making in Mali is affected by two major problems:

- communication deficiencies (information exchange and equipment);
- lack of intervention thresholds established according to the different types of situations that may come up.

In our opinion, as long as these problems are not resolved, "false starts" and surprise situations can always happen, situations which are used to justify emergency support each time.

5.2 Training for Control Operations by the CPS

5.2.1 Training for Agents

Training by staff of the CPS, which is one of the preparatory measures of the locust/grasshopper control campaign, takes place on three levels, as noted above. Training takes place between February and May of each year and is developed around the following themes:

- recognizing different types of locusts and grasshoppers;
- overseeing the development of the locust/grasshopper population, collecting and transmitting information;
- control methods;
- pesticides used in locust/grasshopper control efforts and how they are managed (storage, application, precautions to take in order to avoid risks);
- radio network maintenance.

It is clear that the details of these different themes will depend on the category of target audience, i.e.:

- **Plant Protection agents** to be trained or retrained (approximately 10 per year). Keeping in mind their role as facilitators and supervisors, the Plant protection agents must receive most of their training in survey and control methods. The base chiefs should be able to evaluate their intervention zone's situation, set treatment objectives, make plans, and implement them.

- **ODR agents** (200-300 per year). These agents can play a very important role in the peasant's mobilization and follow-up, provided that they are assigned specific tasks. They can also play an important role in information collection and dissemination. Their training must be oriented around these objectives.

- *Military units were involved in the 1989 campaign, during which 185*

soldiers received training.

5.2.2 Farmer-level Training: Village Brigades

The peasants can play the main role in campaigns, through, for example, surveillance, communicating observations, destroying egg pods, controlling larval bands -- if the time and effort are put forth to train them. Training for peasant awareness has been a generalized operation since 1985 in the zones where the locust/grasshopper problem is characteristically endemic, but the training of intervention brigades at the village level started one year later.

These brigades, usually composed of 10 young people chosen during awareness training, go through training (of approximately three days) that is rather advanced in the amount of information given them. They receive a certain amount of pesticides (5% a.i. or less in powder form) and a portion of treatment and protection materials. These young people receive follow-up training from the Plant Protection staff and are responsible for control operations at the village level.

This training is most active in outlying areas away from centers of activity such as Haute Vallée (where parastatals and development agencies already operate, thus awareness likely to be greater). During 1989, about 224 village plant protection brigades were trained, and in 1990, about 466, or about 2240 and 4660 peasants, respectively (S.P.V. 1991). These village brigades and other trained farmers are assuming an increasingly important role in the national plant protection scene, a trend referred to above (5.1).

It should be noted that the public health service system has a training cadre which should be linked with the training provided by the CPS. Likewise, the amount, frequency and quality of training are in need of improvement.

5.2.2.1 Evaluation of Village Brigades in the Sahel: Findings

In September 1990, an FAO/OCLALAV team headed by C. Castleton of USDA/APHIS (Africa Area office, Abidjan) made a rapid assessment of the use of village brigades in Mali's grasshopper control campaign -- as also of Senegal's and Chad's (Castleton 1991). The principal findings for Mali included:

a. At least 8,000 villagers have been organized and trained by the CPS.

b. The CPS has shown good initiative in working collaboratively with the Centre d'Animation Rurale (CAR) and NGO's such as SECAMA.

c. The CPS has taken the first steps towards the involvement of women by organizing a women's brigade near Mopti.

d. In some heavily infested areas, village brigades account for up to 25% of the total surface area treated. In lesser infestations they may represent 100%.

e. There is active use in most brigades of alternative control techniques such as egg pod destruction, flailing of young nymphs, bagging of insects and the use of fire. Digging of trenches for burial of marching desert locust nymphs was practiced widely in some areas during the recent plague. Interest in alternative techniques varied with ethnic group, and worked best where incentives were provided.

f. Although new brigades are organized each year, no system exists for upgrading their training.

g. The supervision of brigade activities varies greatly. In the worst case, brigades may be organized and never again visited (the CPS agent is unsure if they ever received equipment or pesticides). On the other hand, SECAMA agents visit each brigade at least monthly, and all applications by the Centre d'Animation Rurale are directly supervised by staff.

h. Several brigades had completely exhausted their pesticide stocks and were inactive during the critical point in the cropping cycle.

i. Several brigades has shifted from dust formulations to the use of EC and ULV, but at great risk to their health and safety. Cases of pesticide poisoning last year, due to liquid formulations, were cited by several agents.

j. The main cause of exposure of villagers to pesticide appears to be lack of protective equipment. There appears also to be some aversion to its use -- masks are thought to be very uncomfortable. Other contributory factors include: diversity of application equipment, inadequacy of practical training, no retraining and lack of supervision.

k. All levels of pesticide storage could do with some improvement, but in no case did existing conditions represent an immediate threat to human health or to the environment.

l. The CPS system of salary supplements to CPS agents seems to be working well, but this generally means some continued donor input.

5.2.2.2 Recommendations of the Evaluation

Recommendations resulting from the village brigade assessment mission are summarized as follows:

a. Suspend all application of EC and ULV formulations by village brigades until such time that the CPS distributes protective equipment.

b. Establish and enforce national directives on the utilization of protective equipment at each level of manipulation (transport, decanting, mixing, etc.).

c. Design protective gear for local manufacture. Uniforms for villagers could be sewn by themselves if printed material and models are provided by CPS. An "Africo-tropicalized" version of protective clothing would aim at light, easily-washable material, and possibly use of headcloth scarves to be wound around the face (a familiar object in everyday use) could be a more acceptable alternative to masks (Popov, pers. commun. 1991).

d. Emphasis should be placed upon the recycling of existing brigades, rather than the organization of additional members.

e. A multi-tiered system of follow-up must be established.

f. Application equipment should be limited to one or two standardized models. Both CPS agents and brigade members should be trained and certified competent in their use.

g. The program of village brigades should be more fully integrated into the national grasshopper control strategy, rather than to be treated as a separate project.

h. The job descriptions of CPS should be revised to include duties relating to village brigades.

i. The CPS should build up its excellent initiative, such as the organization of women's brigades, the use of alternative control methods and the use of village brigades to control other pests.

j. Small scale of field trials need to be conducted on the use of biocontrol formulations in areas of difficult access (cliffs or the Dogon people) and the efficacy of egg pod destruction.

k. Training material needs to be developed and distributed to cover pest identification, pesticide application, pesticide storage, health precaution, etc. This could include printed yard goods, instructive games, identification charts. Some material is already available in neighboring countries and could be accessed through CILSS.

5.3 Control Operations and Approaches at the National Level

5.3.1 CPS Operations Independent of the Donors

So far, the Plant Protection Service (CPS), created during a locust/grasshopper invasion, has benefitted from the intervention of donors in all areas of locust/grasshopper control efforts. On the other hand, activities such as the efforts to control grain-eating birds, rodents and stem and head borers are not covered by donors, on the whole. The CPS is dealing with a variety of structural problems, such as transmission and storage of field data, informing and equipping the peasants within the framework of protecting areas near their own fields, control methods for pests other than

locusts and grasshoppers. Meloid and scarab beetles, and granivorous birds, have seen upsurges in recent seasons.

During the past five years, an average of 516,000 ha has been treated per year. In 1990, a total of 459,471 ha (87 % of the infested area) was treated, of which 25 % was by aerial means (S.P.V. 1991a,b). The figures for the past five seasons are given below (S.P.V. 1991b):

Season	Surface Area (ha)	
	Treated	Infested
1986 - 1987	595,337	1,000,000
1987 - 1988	330,597	800,000
1988 - 1989	502,098	1,200,000
1989 - 1990	722,492	1,500,000
1990 - 1991	459,471	525,000

Thus, in 1989/90, under 25 % of the surface area treated was the work of the peasants, while in 1990/91, about 50 % of all terrestrial treatments were conducted by them (S.P.V. 1991b). This is consistent with the governmental policy of decentralization, but also calls for particular attention to the implications for the safety of the peasants involved. This aspect is dealt with in Sect. 5.2.2 above.

5.3.2 Terrestrial Operations

The approach to dealing with acridids depends very much on whether locusts or grasshoppers are involved.

Locusts. The strategy against desert locusts emphasizes preventive control, involving intensive surveillance in the Desert locust's recession breeding areas: Adrar des Iforhas, Tamesna, Timetrine and, recently, Gourma. Up to three teams operate out of the Gao unit. The migratory locust breeds in the Interior Delta, where preventive control work has managed to keep this locust under control for about 40 years. However, since the late 1960's as a result of climatic and environmental changes in the Delta, the outbreak potential of this locust has diminished. The objective of preventive control is to prevent gregarization, so as to reduce the chances of having large swarms form which can reach areas of crop cultivation, and begin a cycle of outbreaks which can spill over into other regions.

The GTZ is proposing (S. Krall, pers. comm., 1990/91) to provide major support to the CPS to allow the proper functioning of the Desert Locust Preventive Control unit in Gao. This is conceived for two years initially, with probable extension to five years or more. GTZ is also considering similar efforts in Mauritania, Algeria, Niger and Sudan. The relationship of these significant initiatives with the proposed IFAD/FAO (1991) Inter-Regional

Preventive Control Plan remains to be determined.

Grasshoppers. Efforts to deal with grasshoppers occur in two main stages. End-of-season assessments of infestations and egg-pod surveys by the CPS are increasngly the basis for planning the early-season control operations, which are conducted mainly by farmers for the protection of early crops. Early steps taken are of a preventive nature: mobilization of peasants to dig up egg pods in and near their fields. As soon as rains begin, systematic control of hatching larvae is undertaken by village brigades, usually by dusting; at the early stages, the nymphs are very susceptible to control measures. The CPS gets involved only where it is its comparative advantage to do so (e.g., areas of difficult access, uninhabited areas, pastures) or if for some reason the control measures are beyond the capacity of the villagers to handle. Digging up of egg pods and early season ground control can have a significant influence on the subsequent development of the grasshopper populations in an area.

The second phase begins as the grains approach maturity (September - November, depending on the crop and region), during which period intensive survey occurs to pinpoint hotspots requiring priority intervention, either to allocate ground-based CPS crews, and village brigades for treatment, or to guide aerial treatment.

5.3.3 Aerial Operations

Up until 1985, aerial treatments for locust/grasshopper (and bird control) in Mali were handled either by the OCLALAV or by the OICMA. The regions involved in these operations have changed little:

- the Desert locust breeding area (Adrar des Iforas, Timetrine and Malian Tamesna);
- the Migratory locust breeding area (edges of the Niger central delta and of the lakes);
- the zone of the Niger office for bird control (Quelea quelea sp., Euplectes oryx, etc.);
- the Yelimane zone for grasshopper control, starting in 1975;
- the Mourdiah zone, since 1985, for grasshopper control

With the creation of the CPS in 1987, it inherited two aircraft from the OPSR for spraying. One aircraft was added in 1988, bringing to three the number in the fleet.

Experience with use of these aircraft in Mali has led to the following conclusions:

- control from the air offers the advantage of being able to cover large infested areas in a very short time;
- air control allows for treatment of difficult-to-reach zones;
- air control is an expensive operation when one considers the expense of fleet maintenance, especially during the inactive season, logistics support, and the large amounts of pesticide used;

- there is no way to fully control the drift of droplets of pesticides sprayed, a problem which constitutes the greatest potential for pollution in aerial applications, especially in the Sahel area where atmospheric conditions are quite variable;
- the fixed-wing aircraft need landing strips requiring frequent upkeep in order to be used. Additionally, the 1988 experience showed the limitations of these landing strips in cases of heavy rainfall: the airplanes had to remain on the ground up to 48 hours after a rainfall of 10 to 20 mm, while the Desert locust situation was very critical in the intervention zones.

In view of these observations, then, the CPS has revised its field strategy by opting for preventative measures on the ground, measures which entail:

- training and awareness among the rural population about the need for and methods of locust/grasshopper control;
- determining principal egg-laying sites and building awareness for the value of unearthing and destroying egg pods;
- increasing the number of teams specially trained for exploration and field treatments (identification and early destruction of early hatching hoppers);
- equipping a greater number of village brigades with products and materials for protection near their crops at the first signs of hoppers.

The basic advantage of such a system is that it addresses specific, more limited targets and thus uses less pesticide, thereby making chemical control less dangerous for the local environment.

5.3.4 Anticipatory Planning

As operations take place, the exploration teams out in the field transmit information on the situation's progress daily to their bases, which in turn transmit them to Bamako headquarters where a program implementation unit analyzes and synthesizes it. After collecting and synthesizing this field data, this group sends it to a technical committee (which meets once a week) that is skilled in making the necessary adjustments within the framework of what is available. In case of unexpected needs during a campaign, this committee organizes a meeting of donors where these new needs are made known in view of the extent of the situation. This meeting is chaired by the Minister of Agriculture.

5.3.5 Coordination with donors and Other National Agencies

The task of coordination is given to the local office of the FAO in collaboration with the CPS. This coordination is necessary to avoid duplication of the donors' interventions. Additionally, there is an administrative unit during the campaigns which allows for good oversight of the situation. This unit, which plays a key role in the operations, consists of:

- <u>Donors Committee</u>: brings together all the countries and groups

involved in the campaign implementation. The Minister of Agriculture presides over this committee and it is scheduled to meet once a month during the campaign.

- Technical Committee: includes the CPS, logistics expert, the FAO programs coordinator and donor representatives (optional). This committee meets every ten days.

- Program Implementation Group: includes the CPS Deputy Director and the heads of divisions involved in the operations. This group analyzes all information received from the field and ensures that technical committee directives are followed.

Concerning coordination with national agencies, the CPS is presently determining those partners who may be interested in these activities, or in the consequences of these activities. It is now a matter of determining the collaborative linkages among these agencies.

5.4 Donor Operations and Decision-Making

5.4.1 *Review of Donors' Activities and Priorities*

From 1985 to the present, USAID has spent approximately $5 million for emergency activities in Mali, making USAID the number one donor with 24 percent of the total commitment. Within the framework of emergency locust activities, the different donors so far have not shown any precise intentions for particular activities. However, during the last three campaigns, the FAC (French Foundation for Aid and Cooperation) has shown a certain interest in supporting the PV air unit by providing seasoned pilots and by replacing the motor of one Cessna 185 aircraft. Along the same lines, a project to support this unit was developed by the French in 1988-1989 but has not had any follow-up. Further, some donors have shown an interest in other specific interventions: that is the case with CIDA which usually finances operations in the region covered by the ODIK and that of the Norwegian NGOs who prefer to work in the region of Kayes-Yélimané and Gourma.

5.4.2 USAID's Intervention Threshold

Future USAID/Mali participation in locust or grasshopper control programs will be guided by a multi-level decision-making process. The level of involvement is expected to correspond to one or more of the below levels of infestation. Each level has been defined in terms of the following parameters: i) crop area infested, ii) duration of the campaign, iii) extent of donor participation; and iv) required funding. These levels are subject to revision as new information and decision-making tools become available[1]:

---

[1] Compare Section 4.3.3 and 4.3.4 on crop loss assessment and simulation modeling. See also 5.4.3 below on decision-trees for crop protection.

Level 0: Level 0 reflects "normal" densities of grasshoppers. Desert locusts, at level 0, would not be a factor with respect to cropped areas, but preventive control in breeding habitats may be occurring. Grasshopper density levels will be at or below the intervention threshold level for a given species. Crop losses from this level of infestation are relatively minor and localized. The Crop Protection Service should be able to carry out any needed spot treatment programs without donor assistance. However, some material or training assistance may be needed to assure this. The expectation of the grasshopper/locust control program is that a gradually strengthened CPS will have increasing ability to maintain locusts in recession and grasshoppers at low levels of infestation without outside intervention. At this "Level zero" of participation, generally only non-chemical technical assistance will be provided. US A.I.D. is committed to continuing to provide assistance at this level. Much of the rest of this document is related to this "zero" level of participation, under the assumption that this technical assistance will contribute to a decreased probability of emergency support at Levels I through III.

Level I: Level I describes a situation with locust or grasshopper populations at levels which may justify additional donor assistance to avoid significant crop loss. In this case, pest densities will be at or slightly above the intervention threshold levels. This level assumes a crop area infested of approx. 50,000 to 300,000 ha. The threat in Level I is also characterized as "localized" in that swarms are less likely to impinge on neighboring nations than at higher levels of infestation. Furthermore, this level infestation is assumed to occur mostly in western Mali where the potential personnel base permits the mobilization of a ground campaign.

Level II: Level II represents high locust or grasshopper densities with large numbers in both crops and pasture lands. Here, l/g densities will exceed the intervention threshold level. Significant crop loss is probable without additional donor assistance and possibly intervention. This level assumes a infestation of on the order of 500 000 ha, primarily within the 15th and 16th parallels near the Mauritanian border and Kolokani, in the Niger Inland Delta, and in the Adrar des Ifhoras breeding grounds. Under this scenario, the potential to swarm to other countries would be greatly increased.

Level III: Level III describes a situation involving very high locust or grasshopper populations extending over a large area. This level assumes a widespread infestation by desert locusts and/or migratory grasshoppers of well over 500 000 ha, and a greatly increased threat to neighboring countries. Under this scenario it is likely that resources not only of GRM but also of donors would be exceeded. Significant crop losses would be expected despite the best possible emergency response. This level of infestation may be expected to require in excess of $10 million. Any contribution by U.S.A.I.D./Bamako would undoubtedly have to be augmented by A.I.D./W.

Because of the complex effects of crop loss, investments by donors at each of the four intervention levels may be justified. At each level, assistance which builds sustainable infrastructure would be most appropriate.

Emergency requests for assistance are met by emergency budget allocations, but long-term support must usually be justified in terms of its economic return. In making specific decisions about the needed level of support, A.I.D. will take into account the need for restraint. Over the last few years, the use of pesticides has been gradually increasing (see Sect. 5.3.1, and Table 1 in Appendix D). This does not seem to be related particularly to annual trends in locust or grasshopper infestations. Instead, it may be related to increasing donor willingness to provide pesticides. Reversal of this trend is essential, and can be accomplished through a

rigorous decision process and increasing attention to non-chemical alternatives, as advocated in this SEA.

Control activities, which up to now have been based on massive pesticide use, are not without dangerous consequences on the environment of the zones treated. Thus, USAID/Mali, from the start of its locust/grasshopper control commitment in Mali, has preferred, in conformity with American policy, to place restrictions on the use of chlorinated hydrocarbon pesticides, which up to now had been the most effective pesticides available. The abandonment of these materials was seen as a necessary part of the cost of doing business, in which environmental concerns took an increasingly significant role.

On the other hand, USAID is actively participating in developing new control methods which tend to minimize pesticide use--all this with a view to better control and environmental protection. This new approach to the locust/grasshopper problem is based on, e.g.:

- research on alternative products which are effective and which minimize the risks to the region: biological pesticides for locusts and grasshoppers. "biorational" products (e.g. growth regulators); new chemicals, and others (see Section 5.5).
- training of different categories of people involved in pesticide management (CPS agents, health service agents, ecologists, trainers, etc.);
- the long-term strategy, which consists of a more realistic approach to the locust/grasshopper problem before it becomes a plague[2]. This involves moving toward reinforcing the different countries' capacity to manage crop protection problems individually in relation to different ecological factors, and transferring the recurrent costs to the governments or the farmers.
- development of better decision-making tools based on crop loss assessment research, cost-benefit analysis, and socio-economic research.

5.4.3 Decision-tree for Sponsors of Crop Protection

A representative decision-tree outlining the types of questions that should be asked when determining a strategy for sponsorship of crop protection is given in Figure 6. While it is presented from an administrator's or economist's perspective, such a decision-tree requires a considerable amount of technical information, and will vary according to whether grasshoppers, desert locusts, or other pests are involved, and according to the crops threatened. Indeed, the very premises of emergency interventions for locust and grasshoppers must be thoroughly reconsidered. The questions asked in the decision-tree are the sort that must be answered if a pest management strategy is to tested for economic viability and financial and technical sustainability.

---

[2] When it is available for donor consideration, the proposed FAO Plan for Preventive Control of the Desert Locust should be considered carefully by USAID for elements which are appropriate for support (IFAD is apparently no longer a co-sponsor). For a related GTZ initiative, see Sect. 5.4.5.

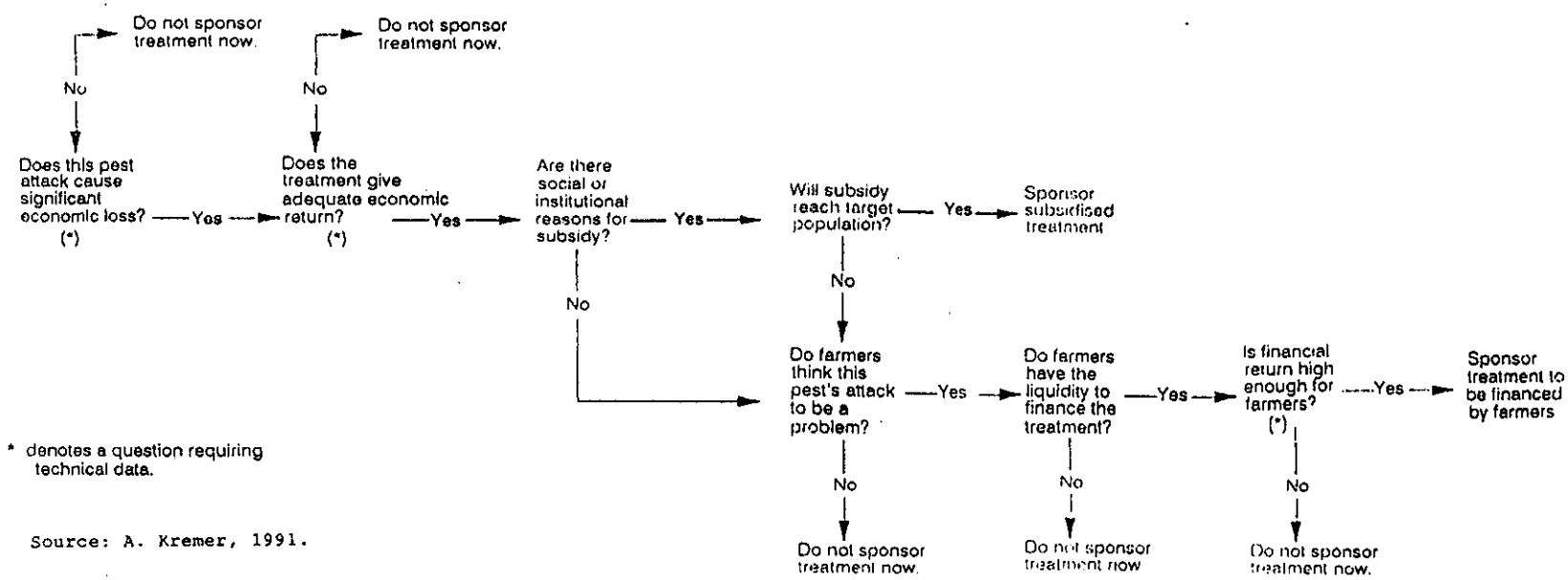


Figure 6. Decision-tree for Sponsors of Crop Protection Activities in the Sahel (from Kremer 1991).

Methodologies available to study these questions, particularly from the socio-economic perspective, are discussed by Kremer (1991). This SEA recommends that such investigations be given carried out, with a priority upon grasshoppers and locusts, in relation to the subsistence farmer growing millet crops in the Sahel. This work should also involve linkages with food security assessment and famine early warning activities.

5.4.4 Procedures for Determining and Verifying Need for Intervention

Presently, the need for intervention is established based on two key criteria:

a. The size of the infestation at the end of the campaign: with the movement of adult locusts and grasshoppers and the estimate of infested zones at campaign's end, a rough first evaluation is made of the areas which may be infested from the beginning of the next rainy season.
b. The next step is a second evaluation made through surveying for egg pods, an evaluation which allows for a much more exact estimate of the true extent of the risk as a function of cultivatable acreage based on a census of the different zones. Naturally, the results are dependent upon the presence of favorable ecological and climatic conditions.

Data obtained in this way allows for oversight of:

- the size of interventions to be implemented;
- the needs for training and equipping the peasants;
- the participation of different entities concerned with the locust/grasshopper problem.

Another approach to determining the need to intervene, other than the approaches discussed in Sect. 4.3, is to construct decision thresholds that are not quantitative. For example:

- With increasing capability in the CPS, all the initial stages of problem identification and control would be the responsibility of GRM.

- If their ability to control the pest were exceeded, a request for assistance could be issued to the donor community. Depending on the level of professional credibility of the CPS at that time, the donor community could obtain an independent judgement by an experienced, objective acridologist (locust/grasshopper entomologist).

- The next decision threshold would be the professional judgment of the entomologist, in consultation with the donor community, about the seriousness of the threat to crop production.

This system is believed to have worked well in response to the grasshopper infestation in Senegal during the autumn of 1989. Grasshoppers were building to what was believed at the time to be a serious problem. At

the time the consulting entomologist conducted an assessment, it was clear that less-than-expected crop loss would result, despite some fairly high population levels of grasshoppers, primarily due to the timing of harvest of the crop.

The above approach has some built-in conservatism. By the time an experienced independent entomologist is in the field, the apparent problem may have receded or the damage may have already occurred. Such a system works well when no-action is the appropriate response, but may fail when a real emergency is developing. Nevertheless, this is the system of choice until better crop loss predictability is possible.

5.4.5 USAID Coordination with Other Donors

During the emergency operations period, USAID/Mali actively participated in the monthly or more frequent donor coordination session called by the FAO Representative and/or the Minister of Agriculture (Sect. 5.3.5). Recomendations in this regard are also made in the AELGA Mid-term Evaluation (Appleby et al. 1989). However, now that USAID/Mali is investing in a longer-term strengthening strategy through its crop protection support project, the SEA evaluation team finds that agencies investing in and working with the CPS are not coordinating their activities to the extent desirable. Cases in point would include:

- the UNDP-funded FAO/Mali CPS (SPV) Strengthening Project (MLI/86/009) has a full agenda of institution-building objectives, but these seemingly are not explicitly coordinated with activities in which A.I.D. has also been involved, such as in village brigade training, grasshopper IPM research and demonstration, warehouse and other infrastructure development ($500,000 for offices and storage facilities at each of the 11 phytosanitary bases alone)(see Sect. 6.3.4). On the other hand, there are activities which the FAO/CPS project apparently does not have the resources to carry out, such as CPS staff training objectives, which is an area other donors could contribute to.

- In a welcome initiative, GTZ proposes to allocate DM 800,000 (approx. $ 500,000) over an initial two-year period to the Mali CPS to strenghen the Gao base and its preparedness for preventive desert locust control in the recession breeding areas of Mali. This will go towards covering operational costs, salaries for seasonal personnel and field allowances for CPS staff, also towards provision of the required equipment, vehicle spare parts, repair and maintenance, but not for new construction. Crop protection for grasshoppers and other pests would be permissible only to the extent it does not conflict with the desert locust prevention and control activities. USAID contributed the services of consultant G. Popov to the strategic planning organized by GTZ with CPS for this activity (Popov 1991). Explicit coordination with USAID by CPS regarding this initiative does not seem to be occurring, however.

- The Natural Resources Institute (Overseas Development Administration, U.K.) has had a Millet Pest Control Project based in the Mourdiah area (Kolikoro sector) since 1985, known colloquially as the Projet Pilote

Britannique. Initmately involving the staff and infrastructure of the Malian CPS, the project has devising pest control measures for milletand sorghum which are technically, economically and socially suitable for implementation by farmers in Sahelian Mali. This project has been very active, but does not involve the (IER), the Malian agricultural research system. However, it has welcomed the collaboration or co-siting of related projects by other organizations, including FAO, USAID, and Ciba-Geigy.

- Ciba-Geigy Corporation has developed a three-year agreement with the Ministry of Agriculture to undertake applied research trials in the field on insect growth regulators, biological control agents, and new pesticides and formulations. The extent of the involvement of the agriculture research staff of IER is not clear. In 1989 and 1990, A.I.D. collaborated with Ciba-Geigy on field trials of biological control agents in the Mourdiah area, but no formal coordination has occurred regarding the GRM and Ciba-Geigy agreement (there has been repeated verbal contact between C-G and A.I.D., however).

The CPS would be well served by establishing a regular coordination mechanism, which would promote the better consolidation of the CPS activities, collaborators, and human resources.

5.5 Alternative Methods of Locust/Grasshopper Management

5.5.1 Traditional Control Methods

Traditional locust control methods vary greatly from one zone to another and range from concrete practices to magic incantations, and prayers. Among these methods are included digging trenches in front of the gregarious larvae, which will then be either buried or burned; brush fires set to destroy the egg pods; noises, etc. It appears that to the extent that traditional pest control methods exist in Mali, they currently are of little effect when one considers the need for crop protection in the face of a rather high rate of pest infestation.

Nevertheless, an examination of these methods shows that the following are worthwhile:

- trench digging to intercept gregarious larval bands
- digging up and destroying egg pods in certain species of grasshoppers.

It has been reported that villagers know areas of high density for grasshopper eggs, where they could be disrupted with minimum effort (Dominique 1989). It is encouraging to note that some NGO's, such as Stromme Foundation and the Aide Eglise Norvegienne (AEN), are actively participating in these activities, and that grasshopper control by farmers is developing actively. Collecting Kraussaria angulifera egg pods by farmers (mostly women and children) during the dry season was instrumental in substanitally reducing infestations in parts of the Dogon country (Douentza to Bandiagara) (Popov

1991, pers. commun.).

On the other hand, a host of non-chemical alternative approaches exist for pests in general, and have been more-or-less successfully employed against a wide range of pests insects. For example, adjustments of the timing of planting or of harvest may be possible, or varieties may be found which develop at different rates than do the commonly planted varieties, or show resistance. It is commonly observed that sorghum is more resistant to attack than is millet. Other cultural methods, such as trap cropping, and intercropping may have merit as well. One should not discount the experience certain innovative indigenous farmers may have made, and thus should be alert to such sources. Simple devices like having tree seedling nurseries in protected courtyards or covering them with mosquito netting can be effective in limiting damage to vulnerable plants (Dominique 1989). Similarly, there can be an association between weeding and reduced grasshopper numbers (Popov 1990), an aspect which will be treated below in Sect. 5.5.2.

5.5.2 Progress Towards Sustainable IPM: Non-Conventional Pest Control Agents and Techniques

Integrated pest management (IPM) is the preferred approach for pest control[3]. IPM is not an alternative to the use of synthetic pesticides; instead it is an integration of methods and a means to control pests which may reduce the use of chemical pesticides by using them more judiciously. Use of early warning and surveillance techniques, economic thresholds, timing of sprays based on the pest population dynamics, and as well as of traditional or non-chemical control agents are among the examples of appropriate and prudent pest management methods. Biological control sensu lato involves the use and managment of living organisms, and will play a central role in the development of sustainable IPM and agricultural systems.

Remote sensing and Greenness maps. Satellite-based weather, vegetation and land surveys, maps, etc., are all likely to be useful for building scientific and institutional capacity in African countries (U.S.Congress 1990). Greenness maps have the greatest immediate potential (see Sect. 5.1.4) for application to desert locust preventive control. However, problems with timely delivery remain, as well as how to get them expeditiously to the field survey teams, even though the maps are now available through AGRHYMET in Niamey. Further applied research, field validation, and refinements in spectral sensitivity are needed for the greenness maps to be of maximum utility, particularly in detecting the newly greening areas when they are still subtle, but suitable for Desert locust brteding. Also, improvements in delivery, particularly to remote bases, are needed.

Egg pod survey. For grasshopper management, the survey for, and destruction of, concentrations of egg pods, represents a promising tool for control, prediction and planning. Major research efforts are needed to validate the predictive value of the surveys. Popov et al. (1990) provide a an excellent original treatment and review of this subject, and offer first rate identification guides to many of the key Sahelian species. Popov's repor (1991) on a training course for "chefs de base" of the crop protections regions of Mali is also very informative.

---

[3] Recommendation # 34 of the PEA makes a number of suggestions which could be considered under the umbrella of IPM,

(1991) on a training course for "chefs de base" of the crop protections regions of Mali is also very informative.

Microbial agents. Research is necessary for microbial agents to be available. The microsporidian *Nosema locustae* has been tested in the U.S. and in parts of Africa for its potential for locust or grasshopper control. Research in this area is proposed in recommendation # 21 of the PEA. Much of this research is being supported by A.I.D./W. Preliminary results from Mali clearly indicate that *Nosema* is unlikely to be suitable for use in an emergency context. Additional work is needed to determine its usefulness in an IPM context for longer term maintenance use. Some insect pathogens, including *N. locustae*, are not very pathogenic in themselves but may be sufficiently debilitating so the host may become more susceptible to other stresses. Such potential interactions should be studied, for example, in combination with growth regulators or other biorational agents. However, it is unlikely that any method will be available for off-the-shelf use in the next two or three years.

When research on microbial pest control agents is conducted in Mali, the microbial preparations must be handled and applied by persons thoroughly familiar with this kind of operation. In the past, the introduction of microbial pest control agents has often suffered failure because of inappropriate handling, and failure has led to the termination of potentially valuable programs. *Nosema*, for example, has a short shelf life and must be used soon after production, or kept cold. When frozen, preparations of Nosema spore concentrates are said to retain their viability for at least three years (John Evans, pers. comm. 1990).

Other areas of research being pursued which may prove fruitful, include use of fungal agents such as Beauveria and Metarrhizium spp. In the summer of 1990, field trials on Beauveria were carried out collaboratively by USAID near Mourdiah, Mali, with the Mali CPS and Ciba-Geigy company, and the technical assistance of Drs. Dan Johnson and Mark Goettel of Agriculture Canada. The Mali tests apparently did not achieve the hoped-for level of success. The full analysis of these results are expected in early 1991. A parallel field trial on Beauveria was also conducted in 1990 on the island of Santiago, Cape Verde, in connection with the A.I.D. cooperative agreement with Montana State University and the national agronomic research institute INIA. The Cape Verde results were more positive, but from the experiences both the Cape Verde and Mali, it is apparent that certain basic research is called for, for example, on thermotolerance, histology of infectivity, strain enhancement, application methodologies and formulations, to improve the performance potential of these fungal pathogens.

Another research recommendation related to microbial control is to search for local and possibly more species specific pathogens. It is reasonable to assume that the large population explosions of locusts or grasshoppers might be conducive to the development of epidemics of endemic pathogens. At the time of population collapses a search for more effective pathogens would be particularly appropriate. Collaboration with laboratories familiar with pathogen isolation is advisable. Several research initiatives along this line are presently in progress, most notably under a multi-donor

funded[3] multi-national project based at the International Institute of Biological Control (IIBC), IITA, and DFPV. Additional research teams. are being supported by USAID (Cape Verde), GTZ (Niger), and the UNDP/FAO Locust Research Advisory Group.

Neem and other indigenous plant-derived insecticidal agents. Recommendation # 35 of the PEA supports further research on the effectiveness of Neem tree extract as an antifeedant. Neem extract has the potential of being a component of IPM strategies and has the potential for being a locally-controlled "cottage industry" in Mali (Strzok et al. 1989). This SEA recommends continued research in this area. Since the neem kernel extract is being tested for use in American pest control, and has an experimental use permit for food use from the U.S. E.P.A., international sponsors might be interested in collaboration in this area of research.

Semiochemicals. These are natural "signal" chemicals -- insect- or plant-produced -- which give behavior-influencing messages of one sort or another to insects. Included in this category are pheromones, emitted by the insects to regulate group behavior, which may be involved in gregarious behavior of locusts. Hormone analogs in desert plants are thought to play a role in the development of locusts. Kairomones are short-range attractants and feeding stimulants which may provide an approach to alternative control technology development. Allomones are repellent or deterrent compounds found in various plants (e.g., neem), some of which may have potential for development in this connection. Research in this field is in its very early stages.

Synthetic insect growth regulators. These types of agents (e.g., diflubenzuron), included in recommendation # 34, are often considered "safe" alternatives to the conventional pesticides because of their different mode of action. Continued research in this area is encouraged, although precautions concerning environmental effects should be considered. Growth regulators, for example, may significantly affect aquatic non-target invertebrate.

Agronomic and cultural techniques. Weeding has been found to be effective in reducing grasshopper numbers under certain circumstances. In an IPM project in the Banamba area of Mali, financed by UNDP/FAO, it was shown that weeding at an early stage of crop growth, and by keeping a strip 2 to 4 m wide weed-free around a field did much to reduce numbers of certain species of grasshoppers (Diallo and Yonli 1991). Consequently, the GRM issued a directive for an intensive weeding campaign in the most severely affected areas (SPV 1991b, Popov 1990). Other components of grasshopper IPM which are being promoted in Mali are i) systematic egg-pod digging and destruction in and around fields, ii) deep plowing of fields before sowing, iii) keeping fields generally clear of weeds, and iv) flailing of concentrations of yound nymphs with branches (Bouaichi 1990; Diallo and Yonli 1991; Popov 1991). Changes in planting and harvesting procedures, habitat management, and use of

---

[3] Donors involved in supporting this research are: A.I.D., CIDA, DGIS, ODA -- U.S., Canadian, Dutch and British, respectively.

resistant crop varieties are further cultural options available to enhance IPM.

Baits. Use of insecticidal baits as an alternative to dusting or spraying has a long history, but the frequency of its use varies greatly. Baits appear to be most used in Senegal, where also some research into alternative carriers (millet, peanut, wheat bran, etc.) and feeding attractants and stimulants (molasses, various vegetable oils) has been carried out Niassy (1990). Wheat bran is an ideal bait, and it is quite readily available in many Sahelian countries, because many of the countries, like Mali, have a wheat processing plant from which wheat bran can be obtained at a reasonable price.

Niassy (1990) recently reviewed experiences with the baiting approach, and evaluated several oils against the Variegated grasshopper (Zonocerus variegatus). He states that the use of baits is very economical and effective on a small scale, especially against nymphs. Its success depends upon accurate survey information so as to be able to identify and treat areas of concentrated hatching at the end of the dry season.

In Mali, an IPM project has undertaken preliminary investigations on the feasibility of baiting. Indications are that, in areas of higher millet production, the peasants may be prepared to use some of their excess or low-quality grain for the preparation of bait. In initial trials, baiting led to a reduction of numbers which was better than that achieved by conventional dusting.

This SEA recommends that applied research on baiting be pursued intensively. Carbaryl would be the pesticide of choice, certainly over propoxur, which is often provided as dust. Microbial agents can also be effectively delivered on bait carriers.

In summary it can be concluded that whenever locust or grasshopper control is implemented in Mali, the principles of IPM should be applied to the extent possible. As soon as results in Mali or elswhere indicate the appropriateness of any biological method, a decision will be made about the extent to which they should be integrated into control programs in Mali. Though this may require additional resources initially, it is expected to save resources in the long run.

6.0. SELECTION AND MANAGEMENT OF PESTICIDES

6.1 Pesticides of Choice

Of the various options for control which exist, the one most often used is chemical control because of short-term effectiveness in reducing insect numbers, and immediate crop protection benefits. Yet this method has numerous drawbacks, among which are: the impact on the environment and especially the health risks associated with the use of chemicals. This section will concentrate on this aspect as it relates to health risks within the scope of insecticide use in grasshopper and Desert locust control.

To judge the acceptability of pesticides in given locations and at specific times, detailed knowledge is needed about the product to be used, its physical and chemical properties as well as the ecosystems involved. The identity of the target species, geographic differences and, in particular, seasonal changes and phenological aspects, must be known. Selecting pesticides to be used in locust/grasshopper control, therefore, requires a knowledge of:

- effectiveness of pesticides used as well as doses of application;
- knowledge of the undesirable effects of the pesticides on useful animals (locust/grasshopper predators and parasites, bees, other non-target insects); and
- residues and their effect upon wild fauna, flora, water, soil, and crops.

The national crop protection service (CPS) is the main agency in Mali whose mission is plant and crop protection. It also intervenes in case of rodent threat by treating with rodenticides. Beginning in 1989, it has increasingly been called to assist in the treatment of infestations by other insects. Even more recently, major swarms of granivorous birds requiring control actions by the CPS have appeared in Mali (S.P.V. 1991a) (see Sect. 5.1 and 5.3.1).

6.1.1. Technical Options

The techniques applied in locust/grasshopper control must be judicious and especially in conformity with FAO directives, just as the choice must correspond to FAO recommendations and to American and Malian legislation. Applications are normally made on a scale the peasants can use, but in times of crisis, the use of powerful ground equipment or aerial application is relied on to treat large areas.

The results of experiments done in Malian locust/grasshopper control (USDA, 1986, Dynamac, 1988) show that carbaryl and malathion can be recommended, due to the fact that these two insecticides are not only effective, but they also present less danger to the environment.

Within the framework of desert locust and grasshopper control, from 1985 to the present, the CPS has used the following products during the various campaigns: chlorpyriphos, fenitrothion, malathion, diazinon, bendiocarb,

Sumicombi (malathion and fenitrothion), carbaryl and cypermethrin. Dieldrin and other chlorinated hydrocarbons were used to a limited extent during the first years of the campaign. Most often used at present are the organophosphates -- chlorpyriphos, malathion, and fenitrothion. The carbamates (carbaryl and propoxur) and pyrethroids (cypermethrin, deltamethrin) are less often used.

See the SPV *Campaign Plan (Plan de Campagne 1990/91)* in Appendix D for additional details about pesticides required for use in a representative season. Also, in Appendix C is the list of pesticides which can be provided and used with caution under U.S. funding of locust and grasshopper programs, assuming a SEA has been approved and an implementation plan is in place.

6.1.2 Pesticide Registration and Labeling

Aspects of regulation and information, namely pesticide registration by the host country and the proper labeling of pesticides, are addressed by PEA recommendations # 27 and 13. The draft legislation on Approval and Control of Pesticides (see Section 3.2.1 above) should include a legal framework for requiring appropriate labelling and registration of pesticides. When that legislation is enacted, a high priority for implementation should be placed on requirements for proper labels. The requirements should be based on scientific and administrative evaluations of the usefulness, potential public health aspects, and country-specific environmental impacts.

The pesticide product label can be effectively used to communicate a number of important properties of the pesticide and precautions appropriate to its use. Knowledge of these aspects of pesticide use could maximize efficacy and cost effectiveness as well as minimize adverse effects on man and the environment. For example, protective measures for the user can be described, as well as first aid measures for the over-exposed individual; precautions recommending against use in certain environments (e.g. marshes), or disposal of containers, as well as the most efficacious application rates for particular pest species.

Such "label improvements" specific for the local needs and environment require a close collaboration among international pesticide experts and the appropriate officials, scientists, and technicians of the GRM. The GRM can insist that pesticide shipments from donor countries are labeled at least as comprehensively as required by donor country's laws and in the predominant language of the recipient country -- French in the case of Mali. In summary, a strong licensing and labeling program by the GRM would be an important step in achieving the safe use of pesticides.

6.1.3 Residue analysis

Residue analysis done after the 1985 campaign for all products used shows that the residue levels may surpass the LMR levels. The post-harvest interval must be respected as a safety measure.

On different varieties of grain, the following values were recorded:

► Millet (dwarf): Residue levels found were not higher than acceptable for cypermethrin, chlorpyrifos, and BHC. But the presence of BHC, even at 0.002 ppm, may constitute a risk. This product is not tolerated, as it has slow-acting, long-term effects.

► Sorghum: The residue levels found are: dieldrin 7.74 ppm; fenitrothion 58 ppm. These figures are alarming.

• Leaves of dwarf millet: High levels of: cypermethrin 7.1 ppm; chlorpyrifos 0.89 ppm. Presence of BHC, not to be tolerated.

The residue levels posed two types of risk:

► Levels surpassing the LMR for dieldrin and fenitrothion on sorghum.

► Presence of BHC on dwarf millet leaves and on grain, which is unacceptable and which can induce long-term liver problems.

► High levels of cypermethrin (7.9 ppm) and chlorpyrifos (0.89 ppm).

It should be noted that since the trials in the zones of Nara-Kayes-Yelimane of the 1985 campaign, dieldrin is no longer used by the Crop Protection Service due to the numerous disadvantages related to its toxicity.

However, dieldrin continues to be used by the Mali Public Health department in the vector control campaign, and it would be advisable to coordinate the use of these products by collaboration of the two sectors, crop protection and public health (see Figure 8c, Sect. 8.3).

6.1.4 Dynamac Corporation Project

Entitled "Pesticide Trials to Control the Senegalese Grasshopper", this project to study the effectiveness of pesticides and their effect on the environment in Mali began in the zones Nara-Dilly in August-September-October, 1987. Its objectives were:

a. Test the efficacy of 8 pesticides (bendiocarb, carbaryl, chlorpyrifos, diazinon, fenitrothion, malathion, lambda cyhalothrin, tralomethrin).

b. Study the effects of pesticides on grasshoppers and acridids and on other species of flora and fauna.

c. Study and do a preliminary evaluation of the effects of pesticide residues on the environment (soil, water, crops, harvests).

Plots chosen for the experiment were sufficiently distant from Nara and Goumbou. However, treatment zones were found to be near groups of nomadic tents. During the Dursban trial, there was a significant risk of persistence and it was necessary to move the tents. During this phase of the trial, not a single case of poisoning was recorded either in the field or in the medical center, where two doctors were consulted frequently.

Preliminary conclusions in the Dynamac report emphasize the following points:

- effectiveness of the products tested on grasshoppers at relatively low doses.
- the absence of a lethal effect on non-target animals: reptiles, birds, mammals.
- absence of symptoms of acute poisoning in non-target fauna.

6.2 Safety Precautions

Concerning pesticide storage, handling, application and calibration, appropriate safety precautions are taken before operations begin. First of all, personnel associated with pesticides receive training regarding the risks of pesticide use, safe handling practices, and protective measures required. The handlers and applicators are provided with, and requested to wear, protective clothing, including masks, suits, boots and gloves.

For ground treatment, the treatment teams always are urged to wear masks and gloves. Village brigades are taught preventive measures during their regular training sessions. This work tends to be done correctly to the extent that the CPS uses trained and experienced staff, notably former OICMA and OCLALAV staff members, and modern equipment. Facilities are provided for wash-up of the treatment crews. Nevertheless, major attention should be given to improvements in village brigade training (see 5.2.2.1).

Precautions are taken during aerial treatments, where the risk of pollution by spray drift is rather great. Attempts are made to warn all people in the area to be treated to cover their water supplies (wells, pots, etc.) and food stocks during the spray periods. They are also advised to stay away as long as possible from the sprayed area. Nomads are being sensitized to the danger of pesticides. Livestock ideally are kept from grazing in the treated areas for several days.

Management of aerial operations tends not yet to be up to the desired standard, as much is left to the judgement of the contracted pilots, who are not always as experienced as desirable. Critically important, for example, is an understanding of the appropriate conditions (time of day, temperature, wind conditions) for treatment. Likewise, ground support, to delineate the target area, guidance to the pilots, evaluation of efficacy, etc., is not always adequate. Areas to avoid (wetlands, protected areas, villages, etc.) are described verbally, and general understandings and conventions exist, but no printed reference material is available. Indeed, national guidelines as to management of aerial operations do not exist in a fully elaborated form. Given that the GRM has three small aircraft in its fleet (see Sect. 5.3.3), and that aircraft contractors are involved in most campaigns, this SEA recommends that aerial operations management strengthening be a priority area for support to the GRM. Both the FAO and A.I.D. are producing guidelines for aerial operations.

Aerial spraying on plots, if carried out with precautions to minimize

contact between the pesticides and man and animals, can be done safely, based on the results of the Dynamac study. Teams operating in the field benefit from the support of the Crop Protection Service and administrative authorities. Two points should be noted:

- follow-up is needed on training and education for nomads and farmers to respect the safety measures relating to the time-limit for staying in treated plots.

- monitoring must be done of identified plots so that nomads do not set up their tents there on the day before the treatment.

6.3 Current Pesticide Management Practices

Good pesticide management requires a good storage site selection; a short-term, medium-, and long-term storage plan; a suitable inventory mechanism for tracking pesticide stocks, and an adequate method for disposing of old stock and empty containers. The Mali CPS pesticide management practices attempt to properly integrate all these parameters, despite the country's limited socio-economic condition.

6.3.1 Insecticide Availability and Distribution

The success of locust/grasshopper control efforts is closely related to the availability of appropriate insecticides at the right time in the zones where intervention takes place. Also, it is always preferable to have the products placed as close as possible to the treatment areas (see 5.4.6).

At the plant protection base level, a monthly inventory of products and materials is made and the results are sent to the CPS Administration in Bamako. Allocation of the products at the base level is accomplished following criteria such as (a) the extent of that sector's locust/grasshopper needs, and (b) the isolation of the sector.

It should be noted that the zones most favored by locusts and grasshoppers are for the most part isolated, sparsely-populated sectors, where access is quite limited in the rainy season. It is desirable therefore that initially prepositioned "security stocks" of locust/grasshopper insecticides and materials be in place at the bases and even down to the village level before the rainy season. After the month of June, treatment operations begin with the hatching of certain species such as Oedaleus senegalensis after two steady rainfalls.

During the campaign, as products are acquired and according to the locust/grasshopper situation of the moment, locust/grasshopper insecticides are sent to the areas to be treated either by rail, road or air. Products generally arrive in Bamako and are then distributed to the different plant health protection bases at Kayes, Nioro, Yelimane, Mourdiah, Niono, Mopti, GAO and San (see Figure 1). Each base then distributes its stock out to its sectors and villages according to the locust/grasshopper situation and the stock distribution infrastructures available.

There is an absence of locust/grasshopper insecticide quality controls on imported products, or during their storage for use in Mali (however, Mali's new toxic wastes law does propose to regulate the importation of pesticides -- see Sect. 3.2.2). It would be useful to have a quality control testing facility for the nation as a whole in order to check pesticides from importation to use. There is an analytical laboratory at the Malian Chemical Company (SMPC), a pesticide formulation unit, but an independent pesticide analysis lab is needed. This SEA supports the principle of establishing such an independent analytical laboratory[1].

6.3.2 Prepositioning of Pesticide Stocks

Prepositioning of pesticide stocks is a necessary part of normal preparation. In general, a supply sufficient for approximately one normal year is appropriate. A supply of this magnitude will suffice for the initial phases of even a heavy infestation (e.g., lasting perhaps two or three months with a Level III outbreak). A greater supply could lead to obsolete stocks if several less-than-normal years occur in sequence.

In making decisions about appropriate quantities and locations of prepositioned pesticides, the factors that should be taken into account include:

- probability of need (with fewer data, or data of less quality, indicating a potential problem, the stockpile should be less);
- shelf life of the pesticide (stockpile less of more unstable products);
- alternative uses for the proposed pesticide (a pesticide with fewer alternate uses should be stockpiled in less quantity);
- quality of the area for storage (the more inadequate the store area, the less pesticide should be stockpiled);
- lag time for ordering from chemical companies (products that can be filled in large orders in a few weeks should not be stockpiled in one-year supplies; pre-purchase agreements with chemical companies could be considered);
- variability of infestations in the proposed location (stockpile less in more variable locations, or be prepared to recall the excess to a central location before the shelf life expires);
- ease of transport to and from other locations with potential for outbreaks (stockpile less in accessible locations);

---

[1] Note also that the establishment of a sub-regional laboratory for analysis of pesticide residues (and the more painstaking analysis needs of countries in the region) has been recommended by the 1989 West African Regional Pesticide Management Workshop sponsored by FAO in Accra, Ghana (FAO 1990), and by the 1991 Journées d'Etudes sur la Protection des Végéteux dans le Sahel (INSAH 1991).

6.3.3 Pesticide Banks

A.I.D. and the EEC established off-shore "pesticide banks" during the 1987/89 locust control campaign, which provided for pre-purchased stocks of pesticides which could be expedited for shipment upon demand (and verification of need). Delivery to the affected country generally was possible within 10-14 days or less. This approach minimized the possibility of having stocks delivered which were in excess of real need, and thus reduced the risk of adding to an already significant obsolete pesticide stocks problem, which resulted from previous campaigns. This SEA recommends that such pesticide banks be established at the earliest opportunity, should another emergency outbreak be declared.

6.3.4 Pesticide storage plan and infrastructures

Locust/grasshopper pesticides can deteriorate and become useless for the purpose for which they were intended. They can also constitute a serious danger when they are not stored properly. Unfortunately, correct locust/grasshopper pesticide storage standards have been found to be violated in most developing countries, a practice which constitutes serious problems for man and for the environment (FAO 1986, WEC 1987, Jensen 1987a). Many products are left exposed in places not fenced in, often in places where people and animals spend a lot of time. They can also be exposed to the sun, to rain and to other poor conditions prohibited by the International Code of Pesticide Conduct.

In Mali, pesticide storage is an important concern. With the increased need for and use of pesticides (which can amount to 250,000 l of liquids and 340 tons of powder per year), adequate storage facilities are at a premium. In Bamako, the key point for receiving and distributing products for use at the bases, there are practically no adequate warehouses owned by the CPS. Those warehouses which do exist are mainly the property of other organizations such as the Peanut and Cereal Integrated Development Operation (ODIPAC), the Haute Vallée Operation (OHV), and the truck-farmer cooperative.

However, there are some storage warehouses in the country at the plant protection base and village group levels. In cases where storage warehouses exist, a great number of deficiencies have been noted, such as lack of ventilation, water, electricity and qualified personnel.

Within the framework of the PNUD/MLI/86/009 project established to build the CPS, work is progressing on the construction of 11 plant health protection bases which have warehouse of 125 to 200 m^2 and office space. These installations are already operational in Douentza, Mopti, San, Yelimane (since 1989) and those of Kayes, Kenieba, Sahelian Nioro, Moloda and Sikasso will become operational in 1990. Additionally, sizeable storage infrastructures inherited from OCLALAV and OICMA already exist. Repair work is needed; in GAO, USAID is working on restoring the warehouses of GAO-ville and Aguelhoc. Table 1 of Appendix E summarizes Mali's pesticide storage conditions.

Whether large or small amounts of locust/grasshopper pesticides and other insecticides are stored, an attempt is made to adhere to the following

storage site conditions:

- isolated from people's homes;
- water available for cleaning, mixing, and for fighting any fires;
- fenced and locked and/or guarded;
- warning signs with symbols and local language and French;
- pesticides stored off the ground;
- protected from the sun;
- good ventilation to avoid toxic vapor concentration;
- good inventory control system;
- have protective gear such as jump suits, boots, gloves, glasses, gas masks, etc.;
- have available a first-aid kit which includes antidotes; and
- have a staff trained in first-aid measures in case of poisoning.

6.4 Disposal of Outdated Pesticides and Empty Pesticide Containers

Disposing of old product stock, pesticide containers and packaging constitutes a serious problem in Mali, as is true for all Sahelian countries experiencing the locust/grasshopper crisis. In fact, since Mali is an outbreak region for Desert locust and African migratory locust populations, the country has benefited from substantial international pesticide donations in fighting these plagues. Two international organizations, the OCLALAV and the OICMA (no longer active) respectively were given the task of controlling these two locust species. Thus large amounts of pesticides were obtained over 20 years ago to control the locust populations threatening sub-Saharan countries. These products, mainly chlorinated hydrocarbon insecticides, were not used because their use was discouraged by developed countries such as the U.S.A. and because the plague went into recession.

As a result, today more than 115,000 liters of obsolete or unwanted pesticide stock, some of it over 20 years old, exists in Mali, including dieldrin 5%, 20%; HCH (BHC) dust powder; parathion; fenitrothion and others (FAO 1989). These products are contained in several kinds of containers such as metal tanks and 200-l metal barrels, generally in poor condition (Table 5).

6.4.1 Disposing of Old Stock

Currently it is difficult to be able to identify such products, since a good many of them have been recycled into containers other than their original ones. It is noteworthy that the majority of these products are in the Gao region where a disposal process may pose less risk to people because much of the region is uninhabited.

A particularly acute situation exists with regard to the stocks of some 60,000 liters of dieldrin and other obsolete pesticides in Tin-Essako, a small remote village in the Mali Tamesna (Halter 1990). This material is in an open yard at slight elevation from the two principal wells of the village. Some of the barrels are leaking, and are within ten meters of one of the wells. While the movement of dieldrin into the soil would be limited (it is adsorbed by the soil, resists leaching, and seldom reaches 20 cm (WHO 1989)), it does have the potential for surface run-off. Construction of "secure" storage pending a

solution is not adequate to the need.

If the stock cannot be moved to a safer location soon, at the very least, a berm must be constructed around the area downhill of the storage area, to prevent surface drainage of dieldrin-contaminated water into the wells. The leaking barrels should be placed in overpack barrels, or their contents carefully transferred to new barrels. As stated by Halter (1990), this is a problem which should be tackled by all the appropriate parties in Mali, and which could be treated as case study on how to tackle a toxic wastes problem as part of its program involving institutional reform in the environmental management sector.

Many disposal alternatives exist for this old stock, such as those listed in Table 6. However, only a few are feasible in Mali. When one considers that most outdated products are liquids in ULV formulations, some of the disposal options listed could be considered in Mali. Particularly promising is high temperature incineration (Huden 1990, USAID 1991, USAID/Niger 1991). Three main options seem appropriate for incineration:

- incineration on-site in a mobile incinerator. This method is still being tested. If it appears conclusive, it can be an alternative for destroying products. A problem is that this method will be very expensive, considering that Mali has no incinerator and one would have to be imported from outside the country;

- incineration in a cement kiln in Mali or nearby country. This option is not feasible because there are no functional or suitable cement kilns available;

- Consolidation and removal of the dieldrin for disposal in a dedicated high-temperature incinerator in a third country. This approach is presently being seriously considered and investigated in Niger for the disposal of some 70,000 liters of dieldrin wastes, based on a proposal made by Shell to USAID/Niger following the West African Regional Pesticide Disposal Workshop in Niamey, January 1990. An operations plan and environmental assessment have been prepared and it is possible that the operation may be implemented during the first half of 1991 (USAID/NIger 1991). Mali would profit by sending an observer, as part of a plan to implement a coordinated solution along the lines suggested by Halter (1990).

6.4.2 Destroying Empty Containers

Locust/grasshopper pesticide containers are kept under the supervision of CPS agents and guards. Empty barrels are stored at plant health protection bases where they can be destroyed or recycled. In GAO during 1988, 83 empty 200-liter barrels of malathion were destroyed with USAID assistance. This destruction included neutralizing (triple rinsing with kerosene), puncturing, crushing and burying the empty barrels, for a cost of over 5,000 F CFA per barrel.

It is within the purview of USAID/Mali to deal with non-waivered excess or obsolete insecticide stocks (such as dieldrin, BHC, etc.) for containment and destruction processes. The SEA recommends that action should be taken to provide unbiased and highly qualified technical assistance to GRM to specifically aid in developing plans for the destruction of empty pesticide containers and unusable stocks.

TABLE 5. Obsolete Pesticide Stocks and their Containers in Mali as of 10 Jan. 1990

LOCATIONS	NAME OF PRODUCT	FORMULATION	TYPE OF CONTAINER	NUMBER OF CONTAINER	AGE OF PRODUCT	QUANTITY OF PRODUCT	OBSERVATIONS
GAO (TIN ESSAKO, GAO VILLE)	Dieldrin		Barrel 200L	245	20 yrs	49.000L	
		5 % DLV	Tank 5.000L	3	20 yrs	9.500L	
	Procidacri	20% DLV	Barrel 200L	85	20 yrs	13.400L	
			Barrel 25L	198	Inconnu	4.950L	
		16% DLV	Barrel 200L	10	14 yrs	2.000L	
NIONO -	Dieldrin	20% DLV	Barrel 25L	192	20 yrs	4.800L	
	Parathion-ethyl	?	Can 5L	36	?	180L	
	Endrin Technical	?	Barrel 175 kg	1	?	150 kg	
NOUKDIAN	HCH (BHC)	25% Powder	Sacks 25 kg	23	4 yrs	575 kg	
KAYES et YELIMANE	Dieldrin	5% DLV	Barrel 200 L	1	5 yrs	200L	
	HCH	Liquid	Barrel 25 L	100	14 yrs	400L	
	Parathion	25% DLV	Barrel 25 L	700		450L	
	Fenitrothion	1000 DLV	Barrel 25 L	200		0	Old Barrels
		50% DLV	Barrels 25 L	600		0	OCLALAV
			Barrel 200 L	40		0	
BAMAKO	Lindane	20%	Barrels 20 L	28	15 yrs	Almost empty	Old Stocks OICMA
	Unknown	Unknown	Barrels 200 L	3		0	"
	Fenitrothion	?	Barrels 60 L	8		0	"
	Procida		Barrels 200 L	70		12.000 L	Reconditioned
	Roussel - Uclaf	16%	Barrels 60 L	300	15 yrs	10.000 L	Old stocks OICMA
TOTAL				2 150		115 000 L 725 Kg	

- Information by Radio from the Chefs de Base
- Site Visit

[1] Moved to Tin Essako, January 1990

7.0 EVALUATION OF IMPACT ON HUMAN HEALTH

Locust and grasshopper control operations Mali have essentially four levels of pesticide use, basically coincident with the four levels of intervention (Sect. 5.4.2): the operational level ("level 0") of the CPS where low or "normal" levels of the pests are controlled in the normal course of agricultural pest control, and the three higher levels ("levels I to III") where locust or grasshopper outbreaks have occurred and increasing levels of intervention and control are required. The potential for adverse human health effect is similarly stratified, in that especially in the emergency state large areas of the country are treated and large amounts of pesticide products are being shipped and distributed. Under all of these conditions prevention of exposure of humans is the best approach to minimizing adverse health impacts.

7.1 Target populations

Human exposure to pesticides and the risk of unexpected occurrence of acute chemical poisoning falls into the following categories in Mali:

7.1.1 Operators:

- Laborers working in a pesticide formulation factory (SMPC) in Mali;
- Workers and handlers responsible for shipping, storage, loading, mixing;
- Applicators, for example, farmers, technical agricultural agents, crop protection agents, and public health agents engaged in treatment activities;
- pilots exposed in spite of protective measures.

Pesticide applicators are generally at the highest risk for any adverse effects, probably several orders of magnitude higher than the general population since they are handling the concentrates, and may spill the products on themselves. In addition to the training and supervision indicated above they should be made thoroughly familiar with the "danger" of the pesticide. They also should be provided with equipment that is in good working condition in order to prevent accidents. Such equipment may include pumps to transfer pesticides (to avoid pouring), body protection in the form of aprons and safety shields for the face, gloves, shoes and full body clothing.

In tropical areas it is particularly important that some form of protection is worn during the short periods while handling the concentrates; somewhat lower levels of protection may be appropriate during the spraying of the diluted pesticides. Exposure of applicators is mostly via the dermal route, and the skin usually provides a significant barrier to the entry of the pesticide into the body. However, if the contamination is left on the skin for a long period penetration occurs nonetheless. Therefore, exposed applicators should wash the exposed areas of their bodies frequently. If water is scarce the wash water could be re-used for diluting pesticides, for example.

PREVIOUS PAGE BLANK

7.1.2 Pesticide re-sellers or retailers

At present, the private sector in pesticides distribution is not well developed, and no certification system or other regulatory procedures govern how pesticides are distributed outside of the parastatals' or of direct CPS or public health agents' control. The main groups at risk under current circumstances are:

- Itinerant peddlers selling pesticides in small containers, not well sealed, with dermal contact possible, and having no label or incorrect labels.

- Itinerant peddlers of disinfectants, having neither training not authorization to carry out what is normally a regulated activity.

7.1.3 Populations at risk

At greatest risk from pesticide treatments, apart from those involved in applications in some way, are the following populations:

- children in treated zones;
- children and adults ingesting pesticide-treated grasshoppers;
- farmers and herders entering or transitting treated zones;
- nomadic and sedentary villagers during treatment campaigns, especially if proper warning has not been given.

The general population is most effectively protected from any adverse health effects by implementing the proper application methodologies. Whether or not the application method is considered safe for the general population depends primarily on the toxicity of the pesticide formulation used, the concentration of the pesticide in the formulation, the frequency of application, and the extent and prevalence of drift of the pesticide. In areas of highest population densities treatment-free perimeters can be observed in order to avoid exposure.

It is believed that the most effective way to reduce the exposure of the general population to an acceptable level is to train, educate, and supervise the applicators. It is also concluded that this training and supervision has to be an ongoing effort and has to be detailed enough to include the differences between individual pesticide active ingredients, formulations, and application methods.

7.2 Public Health Delivery System

The public health delivery system in Mali is well structured, although the ratio of public health care personnel to population is beneath WHO recommended norms. The structure of these services varies according to the level: national, regional and local (including county-seats and Bamako communities). Table 7 shows categories of health personnel per capita in Mali.

Table 7. Broad categories of health personnel per capita, per region, in Mali in 1987.

		No. of agents per 1,000,000 inhab.			
REGIONS	POPULATIONS	Highest traing.	Interm. staff	Agents at Bases	Village agents
Kayes	1,058,575	26	90	231	580
Koulikoro	1,180,260	13	68	367	1,102
Sikasso	1,308,828	15	89	404	1,137
Ségou	1,328,250	25	97	194	667
Mopti	1,261,383	18	88	278	566
Tombouctou	453,032	29	68	205	110
Gao	384,734	24	122	315	565
Bamako	646,225	31	371	568	-
MALI	7,620,225	22	110	317	756

Source: Statistical Directory, Min. Santée Publique (MSP-SA/DNPFSS), 1988

7.2.1 The health pyramid in Mali

► Villages. A village typically has a hut for medical care and a village pharmacy. Their equipment and personnel (sanitarian, first aid technician, midwife, etc.) are normally prepared to deal with medical treatment of poisoning cases only during widespread pesticide treatment campaigns. This personnel can participate in public awareness campaigns to keep people out of treated fields and to respect the security of pesticide storage areas.

► Sector. Made up of 5 to 6 villages: the health center of the development sector (Centre de Santé du Secteur de Développement -- CSDD) is run by a nurse's aide. If the aide receives appropriate training, he/she can identify cases of pesticide poisoning and administer first

aid while awaiting evacuation to the district health center.

▸ District health center (Centre de Santé d'Arrondissement - CSA): The infrastructure and personnel of the CSA includes a dispensary, a maternity ward a state nurse, a head nurse and a matron. The CSA therefore has the potential to identify and treat pesticide poisoning cases. Nevertheless, the following measures will be necessary:

- training on the health aspects of pesticide use;
- equipping the center with material and medicine necessary for treating poisoning cases.

The CSA personnel should play an important role in:

- participation in preparing for the pesticide treatment campaign by collaboration with crop protection agents;
- participation in monitoring the public after the campaign to detect delayed or chronic symptoms of poisoning.

In comparison, personnel conducting crop protection treatment are located in the following areas:

a) in villages at the sector level
b) frequently in districts (arrondissements)
c) rarely in local county seats (chefs-lieux de cercle)
d) never in regional county seats (chef-lieux de region).

7.2.2 Conclusions and recommendations: improved health care as related to pesticide use

It is concluded that a serious pesticide incident could be handled only at the higher levels of the health care system; the staffing of the lower level (the village) appears not to be equipped to handle an unusual emergency case. The entire health care system in regions where pesticides are commonly used should be provided with information materials concerning the pesticide uses. The personnel of these centers should also be given the necessary training to recognize and treat the occasional poisoning case they may encounter, as specified in the EPA handbook on recognition and treatment of pesticide poisonings (Morgan 1989), and in the GIFAP booklet on pesticide poisoning (GIFAP 1988?).

The general public, which is believed to be at minimal risk if the necessary precautions are taken, should nevertheless be informed about pesticide uses in the area. This could be achieved by a number of means, such as posters, the radio, and local newspapers as given in PEA recommendations # 15 - 17.

Since the health care delivery system in Mali is not currently prepared to handle a serious case of poisoning in remote areas, each crew of applicators should be self-sufficient in handling an emergency. This requires

that the supervisor is not only familiar with the safe handling of pesticides but also that he can administer first aid, including administering antidotes in critical situations. The supervisor also should be familiar with the early warning signs of poisoning in order that he may remove workers from immediate contacts with the pesticides, thus avoiding more serious effects.

Reports of adverse effects at any level, i.e. general population or applicators, should be reported to the managerial level of the pesticide use program. Depending on the frequency, and most importantly the seriousness of the adverse effects, appropriate steps should be taken to avoid any future occurrences.

Methods of training and extension must be coordinated with crop protection agents. Collaboration is needed between the village brigades and the health and social services, such as the hygienist, first aid technicians, nurses, nurse's aides, community development technicians (Technicien de Developpement Communautaire -- TDC), etc. The TDC is capable of inspiring the village brigades by using appropriate teaching methods in relation to the socio-cultural environment, eliciting a positive reaction of the population to the dangers and benefits inherent to pesticide use.

7.3 Evaluation of the risks of pesticide poisoning

There has not been a comprehensive study of pesticide poisoning incidents in Mali. However, a session on poisoning incidents was conducted during a seminar on "Health Aspects of Pesticide Application" (with special emphasis on the locust campaign, financed by USAID in collaboration with the National Crop Protection Service), held in Bamako from May 29 to June 3, 1989. During this session on poisoning incidents, several specific cases were raised and discussed:

<u>CMDT Zone:</u>
- 2 cases of accidental poisoning with dieldrin;
- 1 suicide with fenitrothion.

<u>Nioro:</u>
- in 1983: acute poisoning of a trainee from the Agricultural Apprenticeship Center during a treatment against millet caterpillars with fenitrothion ULV;
- in 1985: 3 cases of acute poisoning of farmers by fenitrothion, with no deaths.

<u>Goumbou:</u>
- mass poisoning of farmers by fenitrothion in the vicinity of a treated storage area, without mortality. Minor problems with headache and dizziness.

<u>Nara:</u>
- In 1985: 3 cases of dieldrin poisoning, which resulted in the death of one farmer; two cases resulted in recoveries, in which cases, the agricultural agent knew the pesticide involved, and sought treatment.

7.4 Education and Training of the Target Populations

This important aspect affects the target population, and strategies will differ according to the different categories of people in contact with pesticides.

7.4.1 Laborers in pesticide formulation factories

At the pesticide formulation and repackaging factory in Bamako, the SMPC, workers may be exposed to high quantities of pesticides. It is important that the administrative authorities of the factory and the workers be conscious of the risks of exposure and of precautions to be taken:

- Information on precautions during handling of pesticides;
- knowledge of the ways in which pesticides penetrate and measures to take to protect the body from such access;
- wearing of protective clothing and use of protective devices;
- application of correct procedures for disposing of pesticide waste and empty pesticide containers;
- periodic medical monitoring (cholinesterase testing of workers using organophosphates, and possibly carbamates).

These precautions also apply also to the parastatal and private firms involved in repackaging and distribution of pesticides (e.g. UNEGOVE, SODEMA)

7.4.2 Populations in zones of widespread treatments

The Crop Protection Service, in collaboration with the administrative authorities, conducts a public awareness campaign before pesticide treatments are done. The techniques must be adapted, especially for the illiterate population, by the use of pictograms and rural radio, and other techniques used by village health workers.

7.4.3 Crop Protection Agents and Public Health Agents involved in vector control

This personnel plays an important role in the use of pesticides and in the decision process regarding health and safety measures carried out in the treated zone.

The seminar on Health Aspects of Pesticide Application (see 7.3 above) was designed for Crop Protection and Health Department agents (DNHPA), in this case the doctors of the health centers located in the treated zones.

The objectives of the seminar were to address:

- knowledge of the different types of pesticides, and the ways that insecticides penetrate the body;
- toxicity of different classes of pesticides and the dangers of their use;
- different types and causes of poisoning;
- identification of acute poisoning by an organophosphate, a carbamate and an organochlorine pesticide;

- rapid treatment of a pesticide poisoning;
- information and awareness of both workers and the public about the toxicity of pesticides and preventive measures.

Knowledge acquired during the seminar will be very useful if measures are taken to create conditions in the field which are conducive to their application, such as:

- equipping the health centers in the treatment zones with materials appropriate for dealing with acute poisoning incidents, such as medicine and resuscitation equipment.
- allocation of emergency medical kits for first aid (with antidotes atropine and contrathon) in areas where pesticides are handled.
- the institution of periodic, repetitive control of cholinesterase level of all CPS and other regular applicators in the treatment zone.

7.5 Exposure Monitoring

7.5.1 Effects of residues on man

It is known that besides the acute poisoning resulting from direct absorption of high quantities of pesticides, environmental residues also present toxicological risks:

- high levels of pesticide residues in grain or fruit can cause acute poisoning by ingestion.

- residues higher than accepted tolerances (LMR) on food can result in chronic toxicity, especially in the case of persistent pesticide such as dieldrin.

- residues can also cause cancer.

7.5.2 *Monitoring of human exposure*

The target populations we have identified are exposed to the risk of either acute or chronic toxicity. There are direct and indirect methods for evaluating the level of poisoning by pesticides. The indirect method is to measure the cholinesterase activity, for which 20% of the initial reading is the sign of severe exposure.

Cholinesterase inhibition testing at SMPC. An investigation was undertaken to confirm that safety measures were being followed at the pesticide formulation factory (SMPC), where the principal products are cypermethrin EC 20% and propoxur EC 200. Of 37 workers, 22 (59%) were given cholinesterase tests, and none of them had a decrease in cholinesterase levels sufficient to require an interruption of work.

The example of the SMPC should be a stimulus to other places where pesticides are handled frequently. The health maintenance of the workers in this factory is due to respect for the mandatory protective measures by the management, and also due to the fact that the factory is relatively new

(1982). It is essential that other sectors involved in pesticide use conduct risk assessments, and it is time that investigations be undertaken on workers at the Crop Protection Service.

7.5.3 Cholinesterase testing vs. residue monitoring

Monitoring the exposed human population is recommended by the PEA, e.g.: recommendation # 18 proposes the measurement of cholinesterase inhibition (ChE) in humans and the development of better analytical methods for use in the field, and recommendation # 33 proposes a case-control study.

The first of these is considered valid for populations exposed to pesticide levels likely to result in a measurable effect and for which pre-exposure measurements are possible. In Mali, only applicators and others in direct contact with concentrated formulations are likely to meet both these conditions. This SEA advocates testing ChE in applicators when organophosphates are used. Indeed, USAID provided a LOVIBOND kit, equipped for 1,000 tests, which was used to start a small monitoring project of Crop Protection Service and other applicators, with the assistance of the public health service. The results of this study should be available in early 1991 (B. Cissé, in litt.).

On the other hand, ChE inhibition by carbamates is quickly reversible and thus the time between exposure and measurement is often more important than the observed level of inhibition. Even with organophosphates, pre-exposure ChE levels must be taken several days before exposure occurs in order to properly interpret the results of the test. This complicates any general population study and possibly would render it invalid. Even when exposure is high, for example as the result of an accident, interpretation is difficult.

Case-control studies are even more questionable. The confounding factors stemming from general population variability and other health problems are certain to mask any "effects" attributable to a minimal exposure to pesticides for the expected duration. Case-control studies under the best of circumstances are often inconclusive and circumstances are not expected to be the "best" in Mali.

On the other hand, the CPS has access to an analytical residue chemistry laboratory (at the SMPC) and is prepared to measure actual residues deposited in pesticide operations. Environmental residue data produced by this laboratory, including residue data on food and feed items, would be much more reliable, relevant and accurate than any biological monitoring. This SEA thus recommends that chemical monitoring of the human environment at the time of large scale pesticide applications is much more appropriate. Such results could be evaluated and incorporated into future programs, i.e. if the environmental residues are not excessive, future pesticide use could follow the previous pattern. Alternatively, if excessive residues are found, future precautions would be indicated.

Recent regional meetings[1] dealing with these issues have recommended the establishment of an independent sub-regional laboratory equipped to deal with residue analysis needs of the countries in the region, inasmuch as the resources to establish and run such a lab are beyond the means of these countries. By the same token, these meetings recommended that national labs should be established which have the capability to do quality control analyses of pesticides distributed within the respective countries.

---

[1] For example: (1) FAO Regional West African Pesticide Management Workshop, Accra, Ghana, Sept. 1989; (2) West African Regional Workshop on Pesticide Disposal, USAID, Niamey, Niger, Jan. 1990; (3) Journées d'Etudes sur la Protection des Végétaux dans le Sahel, INSAH-UCTR/PV, Bamako, Mali, Jan. 1991.

8.0 ENVIRONMENT AND NON-TARGET ORGANISMS

8.1 Natural Resources and Economy

Agriculture is the major economic activity that depends on the natural resources of Mali. The economy of the country is based on agriculture and consequently depends on rainfall. Since rainfall is inadequate for more than half of the country, agriculture is concentrated in the center, in the west, in the south and in the southwestern portions of the country. Agriculture is covered in more detail in Section 4 above.

A second major way that natural resources of Mali support economic activity is through fisheries. Fish culture (aquaculture) has been practiced since antiquity. This activity is mainly concentrated along the Niger river and in the Interior Delta region, as well as in the ox-bow lakes caused by the bend in the river. The principal centers of pisciculture are: Ségou, Mopti and Gao.

The continuing productivity of the fishery resource of the Niger Inland Delta and the rivers of Mali depends on protection of the stocks of fish. This requires not only maintaining parent stocks of fish, currently threatened by over fishing (Warshall 1989) but also a productive food chain. The food chain leading to the fishery resource can be threatened by the pesticides used in grasshopper and locust control. Aquatic invertebrates may be especially vulnerable; if their population levels are greatly reduced, the loss of fish production will also be great.

A third way that Mali can benefit economically from its natural resources is through non-consumptive uses, such as tourism. Though Mali has not developed activities such as photographic safaris, the potential exists and deserves protection. The major species type believed to be vulnerable to grasshopper and locust pesticides are birds. Birds are not only indirectly at risk through effects on their food chain, but also are directly at risk. Some of the approved pesticides are especially toxic to birds.

8.2 Biotic Zones of Mali

Biotic zones of Mali basically coincide with the agrogeological zones established by the Inventory of Land Resources Project (PIRT) as the result of a combination of geological, ecological and climatic zoning, as described in Sect. 4.1. These zones are presented in Figures 3 and 7.

The biotic zones equivalent to the agroclimatic zones can be named as follows: 1) desert with various degrees of vegetation, 2) the Adrar des Iforas (northern Sahel transition zone), 3) the Acacia-dominated deciduous brushland and wooded grassland (Sahelo-Sudanian zone), 4) undifferentiated Sudanian woodland, 5) the Niger Inland Delta with various types of submersed and emergent vegetation, and 6) Sudanian woodland with abundant Isoberlinia.

A brief overview of the biotic zones follows, with particular emphasis upon the resources most vulnerable to pesticide use. Earlier, these zones

were discussed from an agricultural and a vegetation perspective (Sect. 4). In Section 8.3 below, the most sensitive areas with respect to pesticide use are described.

1. Saharan Zone. Subterranean water sources are said to be abundant, and located at variable depths. In some cases, they are salty. Surface waters are limited to the Niger River, to the oases, to the wadis and a few ponds. The Sahara zone shelters some wild animals particularly adapted to the climate (gazelles, moufflons, addax, etc.), as well as predators, reptiles, birds and insects -- particularly *Schistocerca gregaria*, in the recession breeding sites, basically coinciding with the wadis and flood plains of the intermittent water courses.

2. Sahelian Zones. The Sahel is the habitat of numerous animal species: gazelles, oryx, etc. Elephants frequent the swamps and ponds of Gourma. The most abundant predators are hyenas, wild cats and jackals. There are also many birds and reptiles.

The Sahel is a land of moving pastures. Animal breeding is the only lifestyle which assures permanent use of the region by the movement from one pasture to another. The increase in both human and animal populations represents a risk for this fragile environment.

3. Sudanian Zones. Important water resources are: Niger and Senegal Rivers, streams (Bani, Baoule, Bafing, Faleme, and others), lakes (Maqui, etc.), ponds, and the like. There are zones with continuous water tables and certain with discontinuous water tables, for which the size, chemical quality and depth have a bearing on the socio-economic cost of use.

Thanks to its relatively more abundant vegetation and water resources, the Sudanian zone provides a good habitat for a varied population of wild animals. More than ever before, man is responsible for the alarming decline of the species and their strength. Elephants and elands, both very threatened, are the representative species for this zone. The Roan antelope and the Hartebeest, although widely hunted, are still to be found. Predators are lions, panthers, jackals and wild cats. The monkeys one sees occasionally in the Sahel are here as their true milieu: patas and *Cynocephalus* occupy the open spaces and cliffs, respectively. Birds are numerous and varied, as are reptiles (vipers, pythons, turtles, lizards, crocodiles), and insects are abundant.

Harmful practices have accented the degradation of the soils and the vegetation: bush fires, cultivation of marginal, easily erodible land, reduction of fallow land is not compensated by organic fertilization, total elimination of trees to mechanize fields which are often too large and bordered by fragile ecosystems, stripping of branches and leaves of trees (such as the baobab and the vene tree) for forage, and leaves and fruit for sauce, etc.

4. North Guinean Zone. This zone corresponds to a mosaic of wooded savannahs and thin forests, these areas both regularly subject to bush fires. The vegetation includes many perennial species.

The valleys are overlaid with a band of thick vegetation and covered forests. This is the domain of the tsetse fly (which spreads sleeping sickness), and of similis or river blindness (onchocerciasis).

In addition to having many more animal species than the Sudanian zone, there are species here in the south which are reminiscent of the large forests, such as chimpanzees.

5. Inland Delta of the Niger River. As it straddles the midpoint between the Sahelian and the Sudanian zones, the geomorphology of the inland delta has made the region biologically and geographically unique. In fact, without upsetting the climatic rhythms of its environment, the inland delta has, so to speak, "created an original atmospheric ambiance". The vegetation of the inland delta has great floral originality. The different types of vegetation of the plains which are seasonally inundated depend on the duration of their submersion.

The Niger Delta, located in the heart of the Sahel, allows the presence of species normally found further south. In the flood zone, birds gather by the millions. Migrating species arrive to spend the winter and leave again in March for the northern hemisphere. It is also a gathering place for many Ethiopian species which reproduce between two migrations. The protection and management of these birds is one of the goals of the project called "Environmental Conservation in the Inland Delta of Niger".

In the aquatic environment, especially of the river, the reduction of flood zones threatens many species. Despite the over-exploitation and vulnerability of certain groups, a rich variety remains: more than 130 species of fish live in the Niger, but hippopotami, otters and other species are subject to abusive hunting and indiscriminate massacre.

8.3 Environmentally Sensitive and Protected Areas in Regard to Pesticide Use

The purposes of protection are to maintain continuous productivity of the natural systems on which local economies depend (for example, fisheries in the Inland Delta and tourism in the Gourma) and to ensure survival of representative ecosystems for their "existence" value (e.g., future identification of pharmaceuticals). Some of the Mali's environmentally sensitive areas, and most of its protected areas, are indicated in Figures 7, 8a and 9b. The areas mentioned below include portions of all the biotic zones.

Those Sahelian zones which are zones of pasture land and agriculture are also the havens of grasshoppers and other acridid species. Consequently, these zones are subject to numerous pesticide treatments. Since these Sahelian zones are therefore subject to considerable disturbances of their ecosystem, they merit particular attention regarding issues of ecology and toxicology. After an assault on its biological balance, a Sahelian ecosystem has very little time to build up its resistance again.

In Mali, there are some very unique ecological communities which contain

were discussed from an agricultural and a vegetation perspective (Sect. 4). In Section 8.3 below, the most sensitive areas with respect to pesticide use are described.

1. Saharan Zone. Subterranean water sources are said to be abundant, and located at variable depths. In some cases, they are salty. Surface waters are limited to the Niger River, to the oases, to the wadis and a few ponds. The Sahara zone shelters some wild animals particularly adapted to the climate (gazelles, moufflons, addax, etc.), as well as predators, reptiles, birds and insects -- particularly *Schistocerca gregaria*, in the recession breeding sites, basically coinciding with the wadis and flood plains of the intermittent water courses.

2. Sahelian Zones. The Sahel is the habitat of numerous animal species: gazelles, oryx, etc. Elephants frequent the swamps and ponds of Gourma. The most abundant predators are hyenas, wild cats and jackals. There are also many birds and reptiles.

The Sahel is a land of moving pastures. Animal breeding is the only lifestyle which assures permanent use of the region by the movement from one pasture to another. The increase in both human and animal populations represents a risk for this fragile environment.

3. Sudanian Zones. Important water resources are: Niger and Senegal Rivers, streams (Bani, Baoule, Bafing, Faleme, and others), lakes (Maqui, etc.), ponds, and the like. There are zones with continuous water tables and certain with discontinuous water tables, for which the size, chemical quality and depth have a bearing on the socio-economic cost of use.

Thanks to its relatively more abundant vegetation and water resources, the Sudanian zone provides a good habitat for a varied population of wild animals. More than ever before, man is responsible for the alarming decline of the species and their strength. Elephants and elands, both very threatened, are the representative species for this zone. The Roan antelope and the Hartebeest, although widely hunted, are still to be found. Predators are lions, panthers, jackals and wild cats. The monkeys one sees occasionally in the Sahel are here as their true milieu: patas and *Cynocephalus* occupy the open spaces and cliffs, respectively. Birds are numerous and varied, as are reptiles (vipers, pythons, turtles, lizards, crocodiles), and insects are abundant.

Harmful practices have accented the degradation of the soils and the vegetation: bush fires, cultivation of marginal, easily erodible land, reduction of fallow land is not compensated by organic fertilization, total elimination of trees to mechanize fields which are often too large and bordered by fragile ecosystems, stripping of branches and leaves of trees (such as the baobab and the vene tree) for forage, and leaves and fruit for sauce, etc.

4. North Guinean Zone. This zone corresponds to a mosaic of wooded savannahs and thin forests, these areas both regularly subject to bush fires. The vegetation includes many perennial species.

the most intact food chains. Among these communities are the Inland Delta and different protected zones which comprise the Boucle de Baoule, the Gourma Reserve (elephant) and the Ansongo-Menaka reserve (Giraffe). These parks and forests are protected and managed by the National Service of Water and Forests. Mali is irrigated by two large rivers, the Niger and the Senegal, by their tributaries and several lakes which are replenished during the flooding of the rainy season. Around these water sources are forest galleries with diverse biological systems which must also be protected.

8.3.1. Designation of Pesticide-free Areas

The main protected reserves, shown in Figure 7, are not treated with insecticides, according to representatives of the Crop Protection Service. In the case of a general treatment of the area, a buffer of at least 2.5 to 3 km around the sensitive zones (classified forests, national parks, water sources) is respected whenever possible.

This SEA continues the spirit of the accords discussed in section 3.2.3 by designating areas in which pesticides are not to be used for grasshopper or locust control. The Niger Inland Delta, an area with several actual or potential RAMSAR sites (Figure 8b) is especially vulnerable to the pesticides used in the grasshopper and locust control program. Birds and aquatic invertebrates, and through the latter, fish productivity, are especially vulnerable. Thus, due to the economic value of the fishery and the international interest in the rich variety of birds, restraint must be exercised in the use of pesticides in the entire Niger Inland Delta. For example, the IUCN project area to the north and to the north-east of Youvarou should not be treated with pesticides for locust or grasshopper control. Traditionally, the CPS has not treated this area, but that tradition has had no legal standing. Identification of this and other equivalent areas as RAMSAR sites, in addition to the designation in this SEA, should give additional status to this prohibition, and be given high priority by GRM.

In addition, pesticide use in other areas of open water and in marshy areas of the Niger Inland Delta, as well as elsewhere in Mali, are not consistent with the intent of this SEA. More careful consideration of whether pesticides are needed to prevent significant crop loss, close supervision of any use, strict adherence to buffer zones, and careful observation for signs of environmental detriment are essential in this area. Furthermore, the Niger Inland Delta should be an area with a high priority for testing traditional and other non-chemical methods of control in order to minimize the use of chemicals. Collaboration with IUCN, CARE and other NGOs working in the area might be especially fruitful.

Areas elsewhere in Mali which should not be treated with pesticides are the Gourma Elephant Reserve, the Ansongo-Menaka Giraffe Reserve, the Boucle du Baoule complex (including the national park and the associated reserves), the Bafing National Park, the recently designated RAMSAR sites, and other areas of open water (such as rivers, lakes, reservoirs, and oases), as well as wetlands areas (Figs. 6, 7a, 8b). In addition, the GRM should consider designating an area for protection within the Falaise de Banfora and should survey oases, regs, hammadas and wadis to determine if protected areas should

be identified in the northern desert areas.

In Mali, the use of pesticides must be banned in heavily irrigated zones (the Inland Delta and the valley of the bight of the Niger), classified forests, etc. Given the diversity of these regions, the campaign to control acridids living in these zones must be carried out with pesticides which are least harmful to non-target species and which are also effective against the target species. Except for the Inland Delta, the Gourma Elephant Reserve, and the elephant range near Nioro du Sahel, these protected zones are not normally in zones of grasshopper outbreaks (Figures 8a, 8b).

A potential concern which needs to be addressed in Mali relates to patterns of multiple pesticide use for different purposes, but which may overlap in time and space (Figure 8c). For example, the use of pesticides on cotton in the CMDT zone is quite heavy (SPV 1991). Likewise, pesticides are used in vector control and other public health programs. For example, areas in the south of Mali for tsetse fly control are treated -- indeed, dieldrin is said still to be used for that purpose, albeit to a limited extent (B. Cissé, INRSP, pers. commun. 1990). Streams are subject to various pesticide treatments against onchocerciasis in southern and western Mali, and focal schistosomiasis treatments are carried out in certain restricted irrigated areas (Figure 8c).

A professionally prepared map showing distribution of the principal acridid species, other pest problems, patterns of pesticide use, and the protected reserves and other environmentally sensitive areas in Mali would be a very useful contribution to the environmental protection of Mali in relation to treatment against acridid and other insect pests. This SEA recommends the production of such a map. While recommendation 6 of the PEA, regarding the protection of environmentally fragile areas, already tends to be informally adhered to in Mali, this needs to be strengthened by precisely prepared maps which can then be distributed to organizations involved in crop and environmental protection, and in vector control.

8.4 Non-target and Endangered Fauna

The use of pesticides in the locust campaign can have a harmful effect on other arthropods which are non-target or beneficial insects, and on avian species and other vertebrates. Sampling done between Bamako and Gao (Everts et al., 1981) and in the zone of Nara-Dilly (Dynamac 1988) gave an inventory of avian fauna, useful, non-target insects and flora in the Sahelian zones visited. Birds encountered were especially insectivores, predatory birds and migratory birds. The number of species recorded in the northeast zone (Appendix F) is higher than that of the northwest. Gao is unique, due to the presence of the Niger River, in that there are many families of birds associated with water, such as the families Ardeidae, Charadriidae, Rallidae, Laridae, Jacanidae, Glarealidae and Phalacrocoracidae.

An estimated five billion birds, belonging to around 200 species, migrate from Eurasia into Africa and back every year. Their migratory pathways are broadly represented in Figure 9a. Throughout the tropics.

migrants from high latitudes tend to occupy habitats that vary climatically, and thus in food availability, from season to season. It is thought that the migrants choose these areas because they contain few permanent local avian residents, which would find living in them difficult during the leaner, drier periods of the year (Kelsey 1991). Clearly, migratory birds represent a major element of biological resources which would be at risk, particularly from large-scale pesticide campaigns in remote areas, seemingly little-frequented by wildlife, but often deceptively so. In particular, it would seem that the arthropod diversity in these areas is under-appreciated.

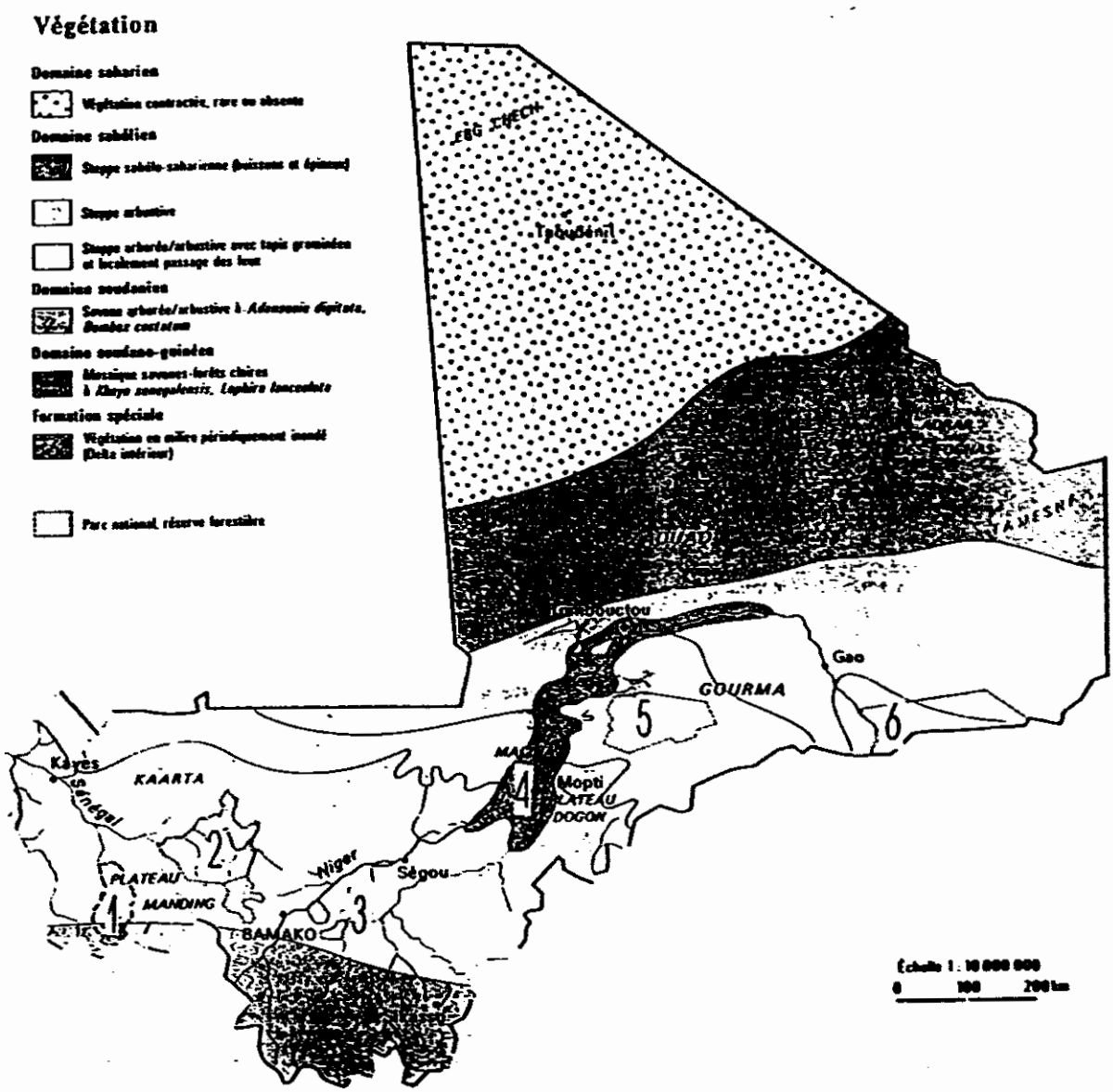
The impact of insects on avian fauna was the object of a study in the Nara/Dilly zone (Dynamac, 1988). In addition, a program of complementary studies was done in Senegal by FAO and USAID (Keith et al. 1990) to evaluate the effect on birds and invertebrates of insecticide treatments applied during the locust campaign. Such studies should be conducted everywhere that large scale insecticide treatments are done.

The list of endangered birds, either at the point of extinction or threatened, is given in Table 8. All of these rare species, and other species completely or partially protected by Malian law, must be subject to preventive measures.

Table 8. Birds Protected by Mali Law

Stork (Whale-headed)	• All carrion-eating birds:
Other Storks (Ciconia spp.)	
Secretary-bird (Serpentaire)	Marabou
Jabiru senegalensis	Oricou
Bald ibis (Ibis chauve)	African gyps vulture
Black-headed cattle heron	(all vultures)
Egretta spp. (all egrets)	
Umbrella bird (Ombrette)	
Spoonbills (Spatules)	
Flamingos	
Crowned Crane (Grue couronnée)	
Ostrich	
Great Abyssinian hornbill (Grand Calao d'Abyssinie)	
*White-fronted Guinea fowl (Pintade à front blanc)	

* Not known to have been found in Mali.



Areas Designated as Pesticide-Free:

1. Bafing National Park
2. Boucle de Baoule National Park and associated reserves (7 710 km^2)
3. Forêt de la Faya (800 km^2)
4. Niger Inland Delta
5. Gourma Elephant Reserve (12 000 km^2)
6. D'Ansonga-Menaka Giraffe Reserve (17 500 km^2)
7. Other smaller reserves and forests

Figure 7. Map of Mali Showing the Protected Areas in the context of the Biotic Zones (Traore 1980).

APPENDIX A

PREPARERS and PERSONS CONTACTED

A.1. LIST OF PREPARERS

CISSÉ, Boubacar S., Prof. de Toxicologie, Ecole Nationale de Medecine et de Pharmacie, Bamako; Chef du Laboratoire de Toxicologie et Bromotologie, Institut National de Recherche en Santé Publique, Bamako.

Diplôme d'Etat de Pharmacien (Option Biologie), Univ. Dakar, 1972
Diplôme d'Etudes Approfondies (D.E.A.) de Physiologie, Univ. Dakar, 1978
Doctorat d'Etat en Sciences Pharmaceutiques (Toxicologie), Univ. Dakar, 1981; Agrégé de Toxicologie, Paris 1987.

DIARRA, Sylvestre Lassana, Chief, Field Trials, Training and Plant Quarantine and Pesticide Legislation, Crop Protection Service (SPV), Bamako, Mali. 1983-84, Chief of Crop Protection, Ségala, Kayes; 1985, Chief of Millet Project (host country counterpart), Projet Pilote Britannique, Mourdiah; 1986-87, Chief of Crop Protection, Nara, Bandiagara.

Dipl. Ingénieur d'Agriculture, and M.S in Entomology, Crop Protection, Oklahoma State University, 1982; Institut Polytechnique Rurale (IPR), 1977, Katibougou, Mali.

DOUMBIA, Yacouba O., Research entomologist, Chief of Crop Protection Service of Institut D'Economie Rurale (IER); former head of Regional IPM project. Diplôme Universitaire d'Etudes Supérieures, Université Dakar 1972; Maitrise de Biologie Animale Université de Toulouse 1974; DEA, Toulouse 1975; Doctorat de Spécialité Animale, Université Toulouse 1977.

KEITA, Moussa, Acting Director, National Crop Protection Service, Ministry of Agriculture, 1990; Deputy Director of the Crop Protection Service (SPV) 1988 -1990.

Ingénieur d'Agriculture (1974); Diplôme d'Etudes post-Universitaires (Universidad de Havana 1977); 1978 chargé d'Etudes Division Productions Animales, OMBEVI.

1979-1981, Chargé des Aménagements pastoraux et agricoles à la Société Lybio-malienne pour le développement de l'Elevage et de l'Agriculture (SOCIMA); 1981-1982, Division Protection des Végétaux (OESR); 1983, Chef de Base Yélimané; 1984-1988, Chef de Section Legislation Phytosanitaire (DNA/OESR).

KNAUSENBERGER, Walter I., AID/AFR/TR/ANR, Pest Management Advisor

BS, Biophysics, 1971, Pennsylvania State U.; M.S., Entomology, 1974; Ph.D., Entomology, Virginia Polytechnic Inst. & St. University; Program Leader, Natural Resources Programs, Virgin Islands

Cooperative Extension Service, Univ. of Virgin Islands, 1985-88; Pest Management Specialist, V.I. Agricultural Exp. Stn., and V.I. Coop. Ext. Serv. U. of V.I., 1980-89; Extension Entomologist, institution as above, 1979-80.

Agricultural development and natural resources assessments in Eastern Caribbean nations (Puerto Rico through Trinidad)

STANLEY, Ronald A., AID/AFR/TR, Environmental Advisor

BS, Botany, 1961, MS, Plant Physiology, 1963, U. of Arkansas; PhD, Ecological Physiology, 1970, Duke U.; MPA, Environmental Management, 1982, U. of Southern California;

Biologist, environmental impact statements, TVA, 1964-75; Assistant Professor of Biology, Memphis State U. & U. of South Dakota, 1975; Biologist, Policy Analyst & Science Manager, EPA, 1976-89; citizen participant on impact assessment review, Fairfax, Virginia, 1986-89; WHO consultant to Greece, impact assessment, 1987-88;

A.2. PERSONS INTERVIEWED

American Embassy
B.P. 34, Bamako, Mali

Hon. Robert M. PRINGLE, Ambassador

Institut d'Economie Rurale
Ministry of Agriculture, GRM, B.P. 258, Bamako, Tel. 22-24-13

Omar TALL, Director General
Dr. Zana SANOGA, Chef de la Division de la Recherche Agronomique [assistant to Omar TALL]
Dr. Kadiatou Touré, Entomologist, Sotuba Station

Service de la Protection des Végétaux (SPV)
Ministry of Agriculture, B.P. 1560, Bamako Tel. 22-24-04

Cheik Omar DAFFÉ, entomologist
Bernhard MAÏGA, entomologist, acridologue
Soumana SOUNTERA, agronomist, Dir. SPV

Division d'Epidémiologie et Prevention, Ministry of Public Health & Welfare, Bamako

Landouré TOURÉ

Ministère de l'Environnement et de l'Elevage
Dr. Moulaye DIALLO, Conseiller au Ministre de L'Elèvage
Dr. Yafong BERTHE, Conseiller au Ministre
Mr. Wélé DIALLO, Chef Cabinet au Ministre de l'Elevage.

USAID/Bamako
B.P. 34, Bamako, Tel. 22-36-02

G. Tracy ATWOOD, Supervisory ADO.
David ATWOOD, ADO
Paul Bartel, FEWS
Dennis J. BRENNAN, Director
Jon BRESLAR, Program Officer, PDO
Amadou CAMARA, Agri. Econ
Don CLARK, Deputy Director
Augustine DAMBELE, Agr. Research
H. Cheick DRAME, Program Specialist, ADO
Oumar DIA, Program Specialist, ADO
Mamadou FOFANA, Coordinator of Grasshopper/Locust Action Group, ADO
Katie KAMPMANN, FEWS Coordinator
Tadesse KIBREAB, Soil Scientist (Ag. Research Tech. Advisor)
Modibo TRAORE, Forester, Program Specialist, ADO
George THOMPSON, Supervisor, GDO
Pham Van VINH, GAG Logistician

FAO/UNDP Project to Create & Strengthen S.V.P. (FAO/MLI/86/009)
B.P. 1820, Bamako, Mali, Tel. 22-24-04, FAX 22-80-24

Dr. J. Andrew FROWD, Chief Technical Consultant
Mr. Taladidia O. Yonli, Entomologist, Consultant

INSAH-UCTR/PV
Daoulé BA Diallo, Coordinator, Technical and Research Coordinating Unit for Crop Protection, Institut du Sahel
Unité de Coordination, UCTR/PV
B.P. 1530, Bamako

Société Malienne des Produits Chimiques (SMPC)
Bamako

Mme Diallo FATIMATA, Chimiste Labo SNPC
Mr. Tamboura CISSÉ, Chef d'usine, SNPC

Ciba-Geigy Corporation

Lona TRAORE, Director, Ciba-Geigy Services
Office of Technical Assistance, B.P. 2461, Bamako, Tel. 22-35-09

Albert MEIER, Vice Director, Product Development for W. Africa
CH-4002, Basel, Switzerland, Tel. 61-697-71-06, FAX 61-697-39-70

I.U.C.N., Mali National Headquarters
B.P. 1567, Bamako, Mali
Mamadou CISSÉ

Other

George POPOV, Acridologist, Consultant to USAID/Mali

Phillipe RUELLE, Consultant Agronomist (to FAO)
Comintrade, Tienne du Sarment 5, 1300 Wavre, Belgium,
Tel. 0032-10-22-77-90, FAX 24-16-40

Kjell CHRISTOPHERSEN, Ecologist
ED/I, Bamako

APPENDIX B

DOCUMENTS PERTAINING TO PROGRAMMATIC ENVIRONMENTAL ASSESSMENT

B.1. Synopsis of Environmental Assessment Recommendations and Priorities as Reflected in the Programmatic Environmental Assessment for Locust/Grasshopper Control. B-2

B.2. Response for Mali to the 38 Recommendations in the Programmatic Environmental Assessment: A basic Pre-Condition of the Program. B-4

APPENDIX B.1. SYNOPSIS OF ENVIRONMENTAL ASSESSMENT PRIORITIES FROM PEA FOR LOCUSTS/GRASSHOPPERS: SUMMARIES OF RECOMMENDATIONS.

OVERARCHING PRIORITY

1. A.I.D. should provide continued support of grasshopper and locust assistance, and evolve toward an IPM approach.

TOP PRIORITY FOR IMMEDIATE IMPLEMENTATION

Inventory and Mapping Procedures:
2. Inventory and mapping of environmentally sensitive areas
3. Dynamic inventory of pesticide chemical stocks
4. Alternative use and disposal pesticide stocks
5. Establish system of inventorying manpower, procedures and equipment

Mitigation of non-target pesticide effects:
6. No pesticide application in environmentally fragile areas
7. Use pesticide with minimal impact on non-target
8. Pre- + post-treatment monitoring

Application of Pesticides:
9. Minimize area to be sprayed
10. Helicopters used for survey & support; aerial spraying only when necessary
11. Small planes favored over large; use experienced contractors
12. T.A. and E.A. expertise be integral in intervention assistance
13. Pesticide containers should be properly labelled - multilingual, esp. French and English (also Arabic)

HIGH PRIORITY AS SOON AS RESOURCES CAN BE ALLOCATED

Disposal of Pesticides:
14. A.I.D. to provide assistance in disposing of empty pesticide containers and obsolete unwanted pesticide

Public Health:
15. Develop public education materials
16. Health personnel training courses
17. Health centers supplied with posters on diagnostic treatment of pesticide poisoning
18. Monitoring human exposure

Pesticide Formulation and Management:
19. Adapt special formulations suitable for tropical climates
20. Develop pesticide container specifications
21. Field test Nosema and other biocontrol agents, including neem.

Training:
22. Comprehensive training for A.I.D. Mission personnel
23. Local programs of training for pesticide storage management, environmental monitoring and public health

24. T.A. teams be given short-term intensive orientation (long-term training if necessary)

Economics:
25. Field research for generating badly needed economic data
26. No pesticide applied unless economic threshold is exceeded

HIGH PRIORITY, WITH POLICY FOCUS/BROADER IMPLICATIONS

Environmental Policy:
27. Assist host countries in strengthening pesticide regulation and environmental policy

Pesticide Use Policy:
28. Promote development of pesticide use policy for all agricultural and public health treatments

Pesticide Handbook:
29. Produce/regularly update pesticide handbook for A.I.D. staff

Support and Training:
30. Develop self-sustaining crop protection services through T.A., education, training plus equipment

DESIRABLE BUT LOWER PRIORITY

Storage:
31. More storage facilities should be built

Forecasting:
32. Should A.I.D. continue funding remote sensing and forecasting or use FAO views?

Public Health Monitoring:
33. Epidemiological case-control studies for areas of expected heavy human exposure

Research:
34. Applied research on efficacy of pesticides and IGRs
35. Applied research on neem anti-feedant
36. Perfect best techniques for toxicological testing

PRIORITY GUIDANCE FOR IMPLEMENTATION

37. Plan of Action developed by A.I.D.
38. Guidelines for A.I.D. to promote common approaches for G/L control

88

APPENDIX B.2. RESPONSES FOR MALI TO THE 38 RECOMMENDATIONS IN THE PROGRAMMATIC ENVIRONMENTAL ASSESSMENT: *BASIC PRE-CONDITION OF PROGRAM.*

Recommendation 1. It is recommended that A.I.D. continue its involvement in Locust and Grasshopper control. Operationally, the approach to be adopted should evolve toward one of integrated pest management.

The Programmatic Environmental Assessment (PEA) made this recommendation a pre-condition for all the others. No program should exist unless it incorporates this principle. This Supplementary Environmental Assessment (SEA) supports that conclusion and is in itself an expression of the commitment to continued involvement. Other recommendations deal with the specifics of evolving toward integrated pest management (IPM), especially numbers 9, 21, 22, 25, 26, 32, 34 and 35.

INVENTORY AND MAPPING PROCEDURES

Recommendation 2. It is recommended that an inventory and mapping program be started to determine the extent and boundaries of environmentally fragile areas.

The PEA made this recommendation a top priority for immediate implementation. This SEA agrees with the high priority and includes specific areas to be protected immediately. In addition, Mali is reviewing a wide range of natural resources laws and standards, including a Pesticides Act. When changes are enacted, relevant portions will be incorporated into the locust and grasshopper control programs.

Recommendation 3. It is recommended that a system for dynamic inventory of pesticide chemical stocks be developed.

The PEA made this recommendation a top priority for immediate implementation based primarily on poor management of large stocks of pesticide products that have accumulated in some sub-Saharan countries. This SEA agrees with the need but believes that Mali has a better than average system of management in place. However, we stress that improvements in the system for managing pesticide stocks should be implemented which will minimize the chance of pesticide products becoming obsolete.

Recommendation 4. It is recommended that A.I.D. take an active role in assisting host countries in identifying alternate use or disposal of pesticide stocks. Refer to recommendation 14.

The PEA made this recommendation a top priority for immediate implementation. This SEA supports that recommendation. Mali has significant quantities of obsolete pesticides, about 115 000 liters of dieldrin, lindane, HCB, parathion, endrin and fenitrothion stored for up to 20 years. The stock in Mali should only be disposed of when the best technology, fitting the local situation, has been developed. High priority should also be placed on recommendation 3, to minimize the future accumulation of any unwanted, obsolete or outdated (ineffective) pesticide.

Recommendation 5. It is recommended that FAO, as lead agency for migratory pest control, be requested to establish a system for the inventory of manpower, procedures and equipment.

The PEA made this recommendation a top priority for immediate implementation. This SEA supports that recommendation in part but carries it beyond a request to FAO, and disagrees in part. This is a general coordination issue, appropriately handled by A.I.D. in Washington (AID/W). AID/W has a major project of cooperation with FAO. As part of a grant of $1.5 million, primarily to implement recommendations 10 and 30, FAO provided forecasting capability and is being encouraged to assist sub-Saharan countries by providing a regional inventory of resources such as these. However, with the current recession of the locust threat, having a regional inventory of manpower and equipment is considered lower priority than it would be in the face of extensive locust or grasshopper swarms.

MITIGATION OF NON-TARGET PESTICIDE EFFECTS

Recommendation 6. It is recommended that there be no pesticide application in environmentally fragile areas and human settlements.

The PEA made this recommendation a top priority for immediate implementation. This SEA supports that recommendation. Any future donations of pesticides should be accompanied by a requirement prohibiting use in some areas and limiting use in others or requiring appropriate buffer zones. These areas include the IUCN project in the Niger Inland Delta, national parks and national forests.

Recommendation 7. It is recommended that pesticides used should be those with the minimum impact on non-target species.

The PEA made this recommendation a top priority for immediate implementation. This SEA supports that recommendation. Pesticide recommendations in the PEA should be followed until research results indicate that more environmentally safe pesticides are available for use. In addition, USAID/Mali will support follow-up studies on the *Nosema* and Beauveria biological control field trials. Investigation of traditional and cultural methods of control is also strongly encouraged.

Recommendation 8. It is recommended that pre- and post-treatment monitoring and sampling of sentinel organisms and water and/or soils be carried out as an integral part of each control campaign.

The PEA made this recommendation a top priority but recognized that difficulties may delay full implementation of this recommendation. A combination of intensive research and a phased approach should be adopted. Special research monitoring is important both as a basis for design of operational monitoring and as a means of establishing statistically verifiable base line data. In addition, periodic "sampling" observations of gross mortality, populations and behavior should be made at locations of major use of pesticides. Since the preliminary results of recent studies in Senegal (see Sect 8.5) indicate that some impacts occurred at twice the recommended rate but

little impact occurred at the recommended rate of application of the most environmentally detrimental pesticides, routine environmental monitoring of every use by individual farmers is not considered essential. Increased training to prevent excessive use is considered essential.

APPLICATION OF INSECTICIDES

Recommendation 9. It is recommended that one of the criteria to be utilized in the selection of control techniques should be the minimization of the area to be sprayed.

The PEA made this recommendation a top priority for immediate implementation. This SEA supports that recommendation. A number of operational procedures should be followed to minimize the area to be sprayed:

(1) Emphasis should be on intensive surveillance; this allows preventive, early treatment in some cases, crop protection treatments when an intervention or economic threshold is approached, or postponing treatment until densities, damage potential, or gregarization occurs, as the case may be.

(2) Emphasis in operations and training should be on recognition and definition of target treatment areas, clear definintion of treatment objectives, and continual elaboration of threshold densities required for intervention to be justified. Training of all decision-making individuals should emphasize the importance of restraint in the use of pesticides.

(3) A program to evaluate the effectiveness of treatments undertaken should be implemented, to allow for refinements in future intervention decisions.

(4) A program of identifying non-treatment areas and minimum treatment areas (protected areas, wetlands, etc.) will be adopted; this will ensure that substantial areas will be excluded from most pesticide treatment.

(5) An option of Food-For-Work, or similar food aid, should be considered in cases where the decision to refrain from aerial application leads to substantial crop loss in a given area.

Recommendation 10. It is recommended that helicopters should be used primarily for survey to support ground and air control units. When aerial treatment is indicated, it should only be when very accurate spraying is necessary, such as close to environmentally fragile areas or for localized treatment.

The PEA made this recommendation a top priority to be implemented immediately. This SEA supports that recommendation. The treatment program in Mali should continue to emphasize ground application. However, this recommendation should be applied with discretion. Much of the treatment occurs during the rainy season and in some areas of Mali are inaccessible except by helicopter. Aerial application guidelines are currently being revised and will be followed when approved.

Recommendation 11. It is recommended that, whenever possible, small planes should be favored over medium to large two or four engine transport types (for application of pesticides). In all cases, experienced contractors will be used.

The PEA made this recommendation a top priority for immediate

implementation. This SEA supports that recommendation. As indicated in the discussion of recommendation 10, the Mali program emphasizes ground application.

Recommendation 12. It is recommended that any USG-funded locust/grasshopper control actions which provide pesticides and other commodities, or aerial or ground application services, include technical assistance and environmental assessment expertise as an integral component of the assistance package.

The PEA made this recommendation a high priority to be implemented as soon as resources can be allocated. This SEA agrees with that recommendation on an interim basis, given the likely continued need for such assistance in the near future. However, this SEA strongly supports the approach given in recommendations 27 and 30 for the longer term. For the short-term a portion of any pesticide assistance should be earmarked for environmental considerations, some of which should be specifically for assisting appropriate host government organizations in developing local expertise in environmental monitoring.

Recommendation 13. It is recommended that all pesticide containers be appropriately labeled.

The PEA made this recommendation a high priority to be implemented as soon as resources can be allocated. This SEA agrees with the recommendation and urges the GRM to give high priority to implementation of labelling as soon as the new Pesticides Act is passed.

DISPOSAL OF INSECTICIDES

Recommendation 14. It is recommended that A.I.D. provide assistance to host governments in disposing of empty pesticide containers and pesticides that are obsolete or no longer usable for the purpose intended. See Rec. 4.

The PEA made this recommendation a high priority, to be implemented as soon as resources can be allocated. This SEA supports that recommendation. Mali's problem with obsolete dieldrin will be dealt with as soon as a suitable disposal method is thoroughly tested. In addition, Mali has a potential problem with improper uses of empty containers. USAID/Mali will assist the CPS in improving the control and monitoring of potential impacts of improper uses for empty pesticide containers, and/or devise a system for safe reuse or disposal.

Particular attention should be given to the solution of the overaged dieldrin stocks problem in Tin-Essako (Sect. 6.4). This should be done in the context of a national case study in dealing with toxic wastes pollution. The experience of Niger in addressing a comparable problem should be taken into account closely.

PUBLIC HEALTH AWARENESS

Recommendation 15. A.I.D. should support the design, reproduction and presentation of public education materials on pesticide safety (e.g., TV, radio, posters, booklets). This would include such subjects as safely using effective pesticides, ecology, pest management of locusts and grasshoppers and the hazards of pesticides. The goal would be to help policy makers and local populations

recognize potential health problems related to pesticide applications.

The PEA made this recommendation a high priority to be implemented as soon as resources can be allocated. This SEA supports that recommendation. Collaboration between the CPS and the Ministry of Health, begun with the writing of this SEA, should continue with the development of public and applicator education in ways to recognize, avoid and treat pesticide poisoning.

Recommendation 16. It is recommended that training courses be designed and developed for health personnel in all areas where pesticides are used frequently.

The PEA made this recommendation a high priority, to be implemented as soon as resources can be allocated. This SEA supports that recommendation and advocates the collaboration mentioned above to achieve the training of the pesticide applicators. Mali has been particularly active in this arena, having organized an Seminar on Health Effects of Pesticides (June 1989) and conducted an assessment of cholinesterase (ChE) inhibition among pesticide applicators. A follow-up to the ChE study is anticipated. These activities have occurred with the close collaboration of public health staff.

Recommendation 17. It is recommended that each health center and dispensary located in an area where pesticide poisonings are expected to occur should be supplied with large wall posters in which the diagnosis and treatment of specific poisonings are depicted. The centers and dispensaries should also be provided, prior to spraying, with those medicines and antidotes required for treatment of poisoning cases.

The PEA made this recommendation a high priority to be implemented as soon as resources can be allocated. This SEA supports that recommendation and advocates collaboration between CPS and the Ministry of Health. Such collaboration already has strong beginnings in Mali, as indicated in Rec. 16.

Recommendation 18. It is recommended that presently available tests for monitoring human exposure to pesticides should be evaluated in the field. This includes measurement of cholinesterase levels in small samples of blood as a screening test.

The PEA made this recommendation a high priority to be implemented as soon as resources can be allocated. This SEA supports the need for monitoring the human health impact of pesticide applications. A Lovibond test kit for an initial 1000 samples have been used for monitoring the individuals most exposed to organophosphate pesticides during the 1990 season. This study will be the subject of a special report and a thesis by students and staff of the School of Public Health. A follow-up study is urged as well. In addition, this SEA favors the monitoring for actual symptoms of pesticide exposure, and environmental residues after pesticide applications.

PESTICIDE FORMULATION AND MANAGEMENT

Recommendation 19. It is recommended that the specifications for A.I.D. purchase of locust/grasshopper insecticides be adapted for all insecticides.

The PEA made this recommendation a high priority to be implemented as soon as resources can be allocated. This SEA supports that recommendation. This is an AID/W activity that should be implemented through a revision of A.I.D.'s Pest Management Guidelines, currently underway.

Recommendation 20. It is recommended that pesticide container specifications be developed.

The PEA made this recommendation a high priority to be implemented as soon as resources can be allocated. This SEA supports that recommendation. This is an AID/W activity that should be implemented through a revision of A.I.D.'s Pest Management Guidelines. In addition, A.I.D. has a representative on EPA's Pesticide Disposal Workgroup that is considering state-of-the-art pesticide container specifications. Any changes in EPA's container regulations that are relevant to A.I.D. will be incorporated in the revised Pest Management Guidelines or provided through other channels to A.I.D./Bamako and GRM.

BIOLOGICAL CONTROL

Recommendation 21. It is recommended that Nosema and other biological agents such as Neem be field tested under African and Asian conditions in priority countries.

The PEA made this recommendation a high priority to be implemented as soon as resources can be allocated. This SEA supports that recommendation in part. AID/W has funded support for *Nosema* and Beauveria field trials in Mali, in cooperation with the CPS and Ciba-Geigy Corp. Preliminary results are disappointing, but follow-up studies will be supported as the project evolves. The need for carefully controlled studies in the area of biological control is stressed by this SEA. Other areas of research should be pursued, especially in regard to native populations of parasites, diseases and predators.

TRAINING

Recommendation 22. It is recommended that a comprehensive training program be developed for A.I.D. Mission personnel who have responsibility for control operations. This will involve a review of existing materials and those under development, in order to save resources.

The PEA made this recommendation a high priority to be implemented as soon as resources can be allocated. This SEA supports that recommendation for Mali. The Operations Handbook (US A.I.D., 1989a) fills this need in part, and a workshop on control operations was held in Dakar in February, 1989. AELGA project workshops have been open to mission personnel.

Recommendation 23. It is recommended that local programs of training be instituted for pesticide storage management, environmental monitoring and public health (see Recommendation 16).

The PEA made this recommendation a high priority to be implemented as soon as resources can be allocated. This SEA supports that recommendation in part.

However, it recommends that the highest priority of training be given to ensure the safe and appropriate application of pesticide products. *This is particularly the case for village brigades, whose training needs to be greatly strengthened.*

Recommendation 24. It is recommended that when technical assistance teams are provided they be given short-term intensive technical training (including language if necessary) and some background in the use and availability of training aids.

The PEA made this recommendation a high priority for implementation as soon as resources can be allocated. This SEA supports that recommendation in general terms but with comment. A preferred approach is to select technical assistance teams which have the best possible expertise and sufficient language fluency for the tasks to be performed. To the extent that any member has a notable gap in language or facility with training aids, short-term training should be provided. If necessary, an interpreter will need to be provided. These teams should include at least one or more members with "senior" expertise; one or more others could be apprentices.

ECONOMICS

Recommendation 25. It is recommended that field research be carried out to generate badly needed economic data on a country-by-country basis.

The PEA made this recommendation a high priority to be implemented as soon as resources can be allocated. This SEA supports that recommendation in general. Implementation consists of two simultaneous approaches. The country-specific approach consists of the agricultural productivity analysis documented herein, and a commitment to keep the database up-to-date on an annual basis. The generic approach consists of an AID/W effort to improve the analytical methodology for Sahelian agriculture, particularly with a focus on simulation modelling. The latter is expected to be difficult and expensive. When it is improved to a level where it is useful, it should be incorporated into a country-specific update.

Recommendation 26. It is recommended that no pesticide be applied unless the provisional economic threshold of locusts or grasshoppers is exceeded.

The PEA made this recommendation a high priority to be implemented as soon as resources can be allocated. We believe that a valid economic threshold cannot be established at this time, and recommend long-term collection of semi-quantitative data to determine the extent to which agricultural productivity is threatened and an effort to ensure that declarations of disaster are supported by valid professional judgement. This would ensure minimum pesticide procurement by limiting A.I.D. participation when a reasonable probability of substantial threat to crops does not exist.

ENVIRONMENTAL POLICY

Recommendation 27. It is recommended that A.I.D. provide assistance to host countries in drawing up regulations on the registration and management of pesticides and the drafting of environmental policy.

The PEA made this recommendation a high priority to be implemented as soon as resources can be allocated. This SEA supports that recommendation. AID/W is engaged in negotiations with EPA to enter into a partnership to provide experts who are knowledgeable in all aspects of pesticide regulations and policies, including human safety, environmental impact, and use, storage, and disposal. It is expected that an expanded interagency agreement will facilitate the implementation of this recommendation. A.I.D./W is also engaged in developing a follow-up mechanism to AELGA.

PESTICIDE USE POLICY

Recommendation 28. It is recommended that a pesticide use inventory covering all treatments in both agricultural and health programs be developed, on a country-by-country basis.

The PEA made this recommendation a high priority to be implemented as soon as resources can be allocated. This SEA supports that recommendation but also considers this to be a topic appropriate for GRM action. USAID/Mali should negotiate with GRM to improve the extent to which a comprehensive inventory is developed. Such a pesticide inventory program should prevent the build-up of obsolete stocks and contribute to a cost reduction in pesticide use in general.

PESTICIDE HANDBOOK

Recommendation 29. It is recommended the A.I.D. produce a regularly updated pesticide handbook for use by its staff.

The PEA made this recommendation a high priority to be implemented as soon as resources can be allocated. This SEA supports that recommendation in principle. This is a centralized function best accomplished by AID/W or REDSO. Among the relevant activities in this area are the following. The Locust/Grasshopper Management Operations Guidebook, updated in January, 1989, covers the specific area of locust and grasshopper control. A similar handbook with broader applicability should be done when the Pest Guidelines are revised. The most appropriate set of country-specific recommendations would take into account the generic A.I.D. policies (as reflected in the revised A.I.D. Pest Management Guidelines (see recommendation 19) as well as efficacy and agricultural productivity, environmental impacts and health effects, safety and mitigative measures. Therefore, the production of this type of handbook implied by this recommendation will be a longer-term effort. However, this SEA recommends the production of a Handbook containing health, safety, and environmental assessments of the pesticides in use in Mali. This type of information is less subject to change than use and application related data. Updating of the health and environmental safety information would only be necessary when new information becomes available, for example through EPA's re-registration (Special Review) process.

SUPPORT AND TRAINING

Recommendation 30. It is recommended that technical assistance, education and training, and equipment be provided crop protection services of host countries with a view to making the services eventually self-sustaining.

The PEA made this recommendation a high priority to be implemented as soon as resources can be allocated. This SEA supports that recommendation. A cornerstone of A.I.D. policy is to help host countries to help themselves become self-sustaining. This has already been achieved to a large extent in Morocco. All activities in the locust/grasshopper control program in Mali will adhere to this principle.

STORAGE

Recommendation 31. It is recommended that more pesticide storage facilities be built. Until that occurs, emergency supplies should be pre-positioned in the United States.

The PEA made this recommendation a desirable but lower priority. This SEA supports that recommendation. Since the locust emergency is over, emergency supplies need not be pre-positioned at this time. Supplies should, however, be built-up at times when field observations indicate that a locust or grasshopper problem is imminent. This SEA provides criteria for deciding about pre-positioning pesticide stocks.

FORECASTING

Recommendation 32. It is recommended that A.I.D. make a decision as to whether to continue funding forecasting and remote sensing or utilize FAO's early warning program.

The PEA made this recommendation a desirable but lower priority. This SEA supports that recommendation but recognizes the difficulties inherent in this choice. FAO provides a regular Desert Locust bulletin, but dose not have an early warning program as such. Any system of forecasting is likely to be flawed at times and choosing one over another may be difficult or impossible. The CPS has somewhat of a forecasting system in place but emphasis should be placed on improving the quality of the data. GTZ is proposing a program of reinforcement of the Preventive Control unit in Gao, beginning 1991.

PUBLIC HEALTH MONITORING AND STUDY

Recommendation 33. It is recommended that a series of epidemiological case-control studies, within the countries involved in locust and grasshopper control, should be implemented in areas of heavy human exposure to pesticides.

The PEA made this recommendation a desirable but lower priority. This SEA argues against this recommendation in Mali. Epidemiological case-control

studies are difficult under the most ideal conditions which monitor the health and the environmental conditions of the participating individuals on a regular and continued basis over a period of several years, possibly a life time. This is believed not to be possible in Mali at this time. Perturbations of the already complex health conditions of the rural Malian population from occasional and minimal pesticide exposures would not be manifested in epidemiological investigations.

RESEARCH

Recommendation 34. It is recommended that applied research be carried out on the efficacy of various pesticides and growth retardants and their application.

The PEA made this recommendation a desirable but lower priority. This SEA supports that recommendation and singles out the search for other microbial pathogens of locust and grasshopper species as a moderately high priority. If disease organisms can be isolated, they might be useful in future control programs. Additionally, the Malian CPS is already engaging in preliminary research on synthetic Insect Growth Regulators (IGR). This research needs further encouragement but with the necessary environmental safeguards regarding the IGRs.

Recommendation 35. It is recommended that applied research be carried out on the use of Neem as an anti-feedant.

The PEA made this recommendation a desirable but lower priority. This SEA concludes that Neem is the most promising current "biological" and thus deserves a higher priority. Some research on Neem is underway. As additional funds are available, the most promising options should be pursued. If Neem extract continues to show promise, a major research effort should be devoted to it.

Recommendation 36. It is recommended that research be carried out to determine the best techniques for assessing the impacts of organophosphates used for locust and grasshopper control "in relation" to the use of these and other chemicals for other pest control programs.

The PEA made this recommendation a desirable but lower priority. This SEA supports that recommendation but considers a higher priority to be appropriate. Considerable funds are being spent under AELGA to conduct comparative impact research. A major international research effort has been launched in Senegal on the ecotoxicological effects of locust insecticides (see Sect. 8.5, and Rec. 8 above)

ENHANCING AND ACCELERATING IMPLEMENTATION

Recommendation 37. It is recommended that A.I.D., on the basis of the previous recommendations, develop a plan of action with practical procedures to provide guidance in locust/grasshopper control to missions in the field.

The PEA included this recommendation to enhance and accelerate the

implementation of Recommendations 1 through 36. This SEA supports that recommendation. AID/W has a general plan of action that includes the development of Supplementary Environmental Assessments in the countries that are most critical for locust and grasshopper control. These countries include Chad, Mali, Mauritania, Niger and Senegal in the region for which the Africa Bureau is responsible. These Supplementary EAs will, in turn, contain commitments for future actions. Country-specific plans of action will be developed to implement those commitments when needed. Such a plan for Mali is outlined in this SEA. The country specific plans of action will be the backbone of guidance for locust/grasshopper control activities. AID/W will work closely with USAID/Mali in the development of plans of action as requested, as AID/W has in the development of this SEA.

Recommendation 38. It is recommended that detailed guidelines be developed for A.I.D. to promote common approaches to locust and grasshopper control and safe pesticide use among UN Agencies and donor nations. Coordination of efforts is becoming increasingly important because of the increasing number and magnitude of multilateral agreements and follow up efforts in subsequent years by various donors.

The PEA included this recommendation to enhance and accelerate the implementation of Recommendations 1 through 36. This SEA supports that recommendation. Coordination occurs both at the AID/W level and the USAID/Mali level. For example, during 1989 and 1990 AID/W funded travel to the 1989 Locust/Grasshopper Conference in Dakar and the 1988-89 Locust Coordinating Committee in Rome. At the country-specific level, the CPS is the major coordinating body but donors also discuss specific plans with each other. These efforts should be improved for the future.

APPENDIX C

PESTICIDES THAT CAN BE PROVIDED

C.1. Pesticides That Can be Provided and Used with Caution in U.S. Funded Locust and Grasshopper Control Operations. Assumes that a Supplemental Environmental Assessment Has Been Approved, and that an Implementation Plan is in Place.

Pesticides that are preferred choices:

Malathion: avoid contaminating water
Carbaryl: avoid exposure to bees
Acephate: must be accompanied by a plan for generating data on efficacy and non-target effects

Pesticides that can be provided and used with caution and with appropriate mitigative measures:

Diazinon: avoid contact with birds
Fenitrothion: avoid contact with birds and all aquatic sites
Propoxur
Bendiocarb
Chlorpyrifos: must be accompanied by a plan for generating data on efficacy and non-target effects

Pesticides for which support can be provided if contamination of water is avoided rigorously:

Cypermethrin
Lambda-cyhalothrin
Tralomethrin

Pesticides that cannot be supported under any circumstances:

BHC
DDVP
DDT
Dieldrin
Lindane

Pesticides under consideration but not approved:

Deltamethrin

APPENDIX D

SUPPORTING MATERIALS RELATED TO PAST AND FUTURE CAMPAIGNS AGAINST GRASSHOPPERS AND LOCUSTS

		Page
D.1.	Insecticides Used By the Crop Protection Service During the Agricultural Campaigns of 1985-1986 to 1989-1990.	D-2
D.2.	Equipment and Pesticide Needs for Phase I of the 1989/90 Campaign.	D-3
D.3.	Evaluation of Storage Conditions for Pesticdes in Mali.	D-5
D.4.	Crop Protection Service Campaign Plan 1990 - 1991	D-6
D.5	Summary of Risks and Benefits of the 1985 Campaign: Case Study	D-14
D.6	Background, Structure and Organigram of the Crop Protection Service as of 1989 (in French).	D-17

Appendix D. Table 1. INSECTICIDES Used by the Crop Protection Service during the agicultural season 1985-1986 to 1989-1990.

P R O `D U C T	QUANTITY BY CAMPAIGN				
	1985/86	1986/87	1987/88	1988/89	1989/90
H.C.H. 25% \.P.	3T595	409T927	-	-	-
Fenitrothion P.P. 3-5% + Unden 2% Dursban 5%	151T145	148T068	78T 218L	339T957	327 L
Fenitrothion EC + ULV (10%, 5% ULV, 50% CE	21 125 L	189 802L	49 218 L	130 114L	142398 L
Dieldrine EEC+ ULV 2%	29 372 L	-	-	-	-
Endosulfan EC 35%	160 L	-	549 L	-	
Diazinon EC + ULV 60%, 9%	-	15 885L	7 310L	-	11725 L
Malathion ULV 96%	1 200L	-	58 365L	104 513L	32665 L
Fenthion ULV 1000, 600	1 390L	-	-	3 925L	-
Lindane ULV 20%, 32 ULV	1 250L	-	-	245L	-
Sumicombi 50%, 60% (Sumicidin + Fenitrothion)	-	2 187L	-	-	-
Ficam ULV (Bendiocarb)	-	-	-	4 994L	1300 L
Dursban 12 EC, 24 ULV (Chlorpyrifos-ethyl)	-	-	-	1 044L	103596 L
Fastac 0,6 ULV (Alpharmetrine)	-	-	-	240L	-
Cypermethrine 12 ULV (Ripcord)	-	-	-	408L	6221 L
Pyrimiphos-methyl (Actellic)	-	-	-	-	120L
Karate 0,8 ULV, 4% ULV (lamda-cyhalothrine)	-	-	-	134L	20300 L
Areas Treated	124174ha	595337ha	330597ha	502 098ha	722 492 ha

APPENDIX D

Tableau 2: Besoins de la phase I campagne 1989/1990 au Mali

DESIGNATION	BESOIN TOTAL	DISPONIBLES	BESOIN A COUVRIR	COUTS EN MILLERS DE CFA	OBSERVATIONS
I. PESTICIDE					
Poudre (fénit. 5% ou propoxur 2%	600 T	180	420	420.000	
Liquides					
concentré émulsifiable	50,000L	0	50,000	150,000	Ces produits couvrent une partie des besoins de la Phase II afin que l'on puis se les mettre en place avant Juillet.
Produit ULV	350,000	0	350,000	875,000	
II. EQUIPEMENT PAYSANS pulvérisateurs conventionnels à pression entretenue	2,750	250	2,500	65,000	
II. VEHICULES			0	0	
Vécules de prospections	30		25	5	35,000
Véhicules de traitement	17	17 dont 13 en commande	0	0	
Véhicule de transport	10	10 dont 8 en commande	0	0	
Véhicule de liaison	8	6	2	14,000	
IV. FRAIS REPARATION					
Parc existant				20,000	
pneumatique		Stock entamé		20,000	
V. CARBURANT LUBRIFIANT					
Mise en Place produit	30.000	0	30.000	5.300	
Prospection & traitement	30.000	0	30.000	6.300	
Lubrifiant				2.500	
VI. PERSONNEL					
Perdiem personnel PV				10.000	
Salaire personnel saisonnier et contractuel				2.500	
VII. MATERIEL CAMPEMENT ET PROTECTION					
Tentes 4/6 Pls	30	10	20		
Lits de camp	150	100	50	30.000	
Tentes individuelles	50	10	40		
Caisse popote	50	10	40	800	
Combinaison	1.500	500	1000	8.500	
Pharmacie					
VIII. HEURES VOL					
Helico	600	0	600	198.000	
Carburant (Jet A1)	120.000	0	120.000	24.000	
Logistique avion	P.M.			P.M.	
IX. PARC AVION					

S.N.P.V.				
Moteur CESNA				12.000
Formation				
pilotes et				15.000
medecins				
Carburant				
(AVGAZ) pr 40H	25.000	0	25.000	6.000
Complément				
pièce de rechange				10.000
Fûts vides				
pour transport				
carburant avion	525	0	525	5.250
Radio E/R	50	32	18	5.000
T O T A L				1.941.150

APPENDICE D' TABLEAU 3 EVALUATION DES CONDITIONS DE STOCKAGE EN MAGASIN AU MALI

LOCALITE	QUALITE	DIMENSION (m)	VENTILATION	TOITURE	SOL	SECURITE			SITUATION		OBSERVATIONS
						ENCLOS	Gardien	Ferme à Clé	En ville	Isolé	
Mopti (Sévaré)	Ciment	15 x 9	Assez bon	Tôle	Ciment	Non	Non	oui	oui	Non	
Douentza	Mauvaise	16 x 6	Mauvaise	locale	table	oui	non	oui	oui	non	en location
Nioro du Sahel	Ciment	30x15x4.5	Bonne	tôle	ciment	oui	-	oui	-		
Yélimané	mauvaise	5x8x4	mauvaise	tôle	terre	non	non	oui	oui	non	
Tambacara	terre	4x4x3	-	tôle	terre				non	oui	
Ségala	ciment	12x7x4	mauvaise	tôle	terre	non	non	oui	non	oui	
Kirané	terre	6x6x2,5	-	tôle	terre			oui	oui	non	
Niogoméra	mauvais	12x8	mauvais	tôle	terre	oui	non	oui	non	oui	
Gao	ciment	10x5x6	mauvais	tôle	ciment	oui	non	oui	non	oui	5 km de Gao
Gao Garage	ciment	60x17x8	bonne	tôle	ciment	oui	oui	oui	oui	non	
Gao I	ciment	6x6x4	bonne	tôle	ciment	oui	oui	oui	oui	non	
Aguelhoc 1	ciment	5x6x4	bonne	tôle	ciment	oui	oui	oui	non	oui	
2	ciment	5x4x7	bonne	tôle	ciment						
Tin-Essako	ciment	5x5x3	mauvaix	tôle							
Kayes Kamou kolé	ciment	28x8x4	assez bon	tôle	ciment	non	non	oui	non	oui	Proche du Puits
Mahina	-	60x30x6	assez bon	tôle			non	oui			CDIPAC
Kéniéba	-	17x8x4	assez bon	tôle	ciment						CDIPAC
Niono	ciment	20x15x5	mauvais	tôle	ciment	oui	oui	oui			50 m du Canal
Molodo	ciment	20x20x5	-								200 m du canal
Niafunké (SDP)	-		assez bonne								500 m du fleuve
Niafunké (PV)	-	20x5x3	bonne			non	oui	non			200 m du fleuve
Tombouctou Agr.	-	4x3x5					oui	oui			
Mourdiah	ciment	-	mauvais	tôle	ciment	non	non	oui	oui		
Dilly	ciment	6x8x3	mauvais	tôle	ciment	-	non	oui	oui		
Nara	ciment	6x8x3	mauvais	tôle	ciment	non	non	oui	oui	oui	
Bamako-ville	ciment	10x17x8	bonne	tôle	ciment	oui	oui	oui	oui		
Bamako-Ballé	ciment	5x8x6	mauvaise	tôle	ciment	non	non	oui	oui		OHV

Appendix D.4. Crop Protection Service Campaign Plan 1990-1991

MINISTERE DE L'AGRICULTURE
SERVICE DE LA PROTECTION
DES VEGETAUX

REPUBLIQUE DU MALI
UN PEUPLE - UN BUT - UNE FOI

PLAN DE CAMPAGNE

1990 - 1991

Bamako, le 4 Avril 1990

I.- INTRODUCTION -

De l'ampleur de l'invasion des sautériaux qui a prévalu à la fin de la dernière saison de mousson et des résultats de la prospection des oothèques, on peut d'ores et déjà prévoir une situation acridienne pour l'année 1990 au moins aussi préoccupante qu'en 1989 si les conditions écoclimatiques devenaient favorables. En effet, lors de la dernière campagne, des vagues d'insectes sont déscendues jusqu'au niveau du 12ème parallèle de latitude Nord où l'on a enregistré de nombreuses ovipositions d'espèces comme Kraussaria angulifera, Oedaleus senegalensis, Kraussela amabile, Cataloïpus cymbifer Hieroglyphus daganensis etc.

Ainsi, il apparaît nettement qu'en plus de la bande Sahélienne où le problème de sautériaux est devenu presque endémique, plusieurs zones des Régions Sud seront concernées lors de la prochaine campagne et ce, dès la fin du mois de Mai où il commence généralement à pleuvoir.

En ce qui concerne le criquet pèlerin, la surveillance sera toujours maintenue dans les aires grégarigènes de l'Adrar des Iforhas, le Tamesna et le Timétrine malgré l'acalmie observée au cours de la campagne.

II.- RESUME DES ACTIVITES DE LA CAMPAGNE 1989/1990 -

Malgré un démarrage tardif des pluies, la campagne 1989/90 a été essentiellement caractérisée par les faits suivants :

- une forte pluviométrie à partir de la deuxième quinzaine de juillet jusqu'en fin Août qui a occasionné des innondations (avec souvent des dégâts) entraînant une paralysie des équipes sur le terrain durant tout le mois d'Août ;

- le criquet pèlerin qui était l'espèce la plus attendue est resté pratiquement inactif malgré des alertes courant Avril et Mai où l'on a enregistré des entrées d'essaims à partir de la Guinée

- les sautériaux, dont le développement avait été masqué par l'ampleur de l'invasion du criquet pèlerin en 1988, ont fait une apparition massive avec le rétablissement de la pluviométrie en Juillet - Août. En Octobre, les superficies infestées atteingnaient plus de 1,5 million d'hectares sur toute la bande Sahélienne du territoire (de Yélimané à Ansongo) et certains secteurs des région sud : Farako, Banamba, Manimpébougou, San et Tominian. Les interventions ont couvert plus de 700.000 ha. Malgré ce chiffre record dans la lutte anti-acridienne au Mali, des dégâts atteignant 60%

Cependant de grandes étendues de jachères sont restées sans traitement et constituent des sources importantes d'infestations pour la campagne I990/9I. A cela il faut ajouter l'important flux migratoir observé à la fin de la saison des pluies. Le résultat des prospections d'oothèques financée par le Projet MLI/86/009 en Décembre I99 laisse présager une campagne I990/9I très préoccupante, il suffit pour cela que la saison des pluies soit bonne et que les autres fac teurs environnementaux soit moins contraignantes.

C.- AUTRES RAVAGEURS - En marge des acridiens, d'autres ravageurs, comme les oiseaux granivores, les rongeurs, et les chenilles des chandelles de mil, les cantharides ect... constituent une menace permanente pour les cultures vivrières. Annuellement des pertes assez importantes dues aux oiseaux granivores sont enregistrées surtout au niveau des périmètres amenagés et dans le Delta du Fleu Niger. Dans les mêmes zones des pullulations de rongeurs servies d dégâts sur semis sont enregistrés.
Les chenilles des chandelles de mil et les cantharides sont entrain de devenir un frein réel à la production du mil dans toute la part Sahélienne du pays.
Les cultures maraîchères subissent des dégâts très importants dus au complexe de ravageurs inféodés et de ravageurs polyphages tel les sautériaux.

Vu le niveau de pullulation de ce complexe de ravageurs cours de la campagne I989/I990 il est probable que ce niveau soit maintenu courant I990 d'où la nécessité d'un programme de surveill et de lutte

IV.- CAMPAGNE I990/I99I -

A)- Objectifs:

1°)- Espèces Visées : La campagne de lutte I989/9I contre les sau riaux a été la plus importante jamais réalisée au Mali.

Elle a été caractérisée par une pullulation exceptionne de toutes les espèces, accompagnée d'une large poussée en directi du Sud, occasionnant des dégâts localement très sévères sur les cultures.

..../....-

- Formation Pilotes et Mécanicien Avion de la Protection des Végétau-

. Formation à l'extérieur du personnel Navigant (2 pilotes) et du mécanicien de l'équipe aérienne qui n'ont pas les qualifications requises sur les types d'avions (CESSNA 185 F ET BN2) dont dispose l' Service de la Protection des Végétaux. Cette formation est estimée à 35 millions de F.CFA. En attendant, les services d'un pilote - instructeur spécialisé dans les traitements agricoles et d'un mécanicie sont nécessaires pour assurer les interventions des avions du SPV et la prise en main des aéronefs par les pilotes du service pour une période de Six (6) mois.

. Formation des Agents O.D.R. -

Les agents des Opérations de Développement Rural constituent un appui non négligeable auprès des paysans dans l'exécution du programme de la Protection des Végétaux. Leur formation en Protection des Végétaux permettra une mobilisation et un suivi plus efficace des paysans, ainsi qu'une plus large collecte et diffusion de l'information. Aussi, à l'instar de la campagne dernière, un objectif de 300 agents est retenu cette année. Ce programme est en cours d'exécutior sur financement du Projet MLI/86/009 Création du Service de la Protec tion des Végétaux.

. Formation des Paysans -

La stratégie de lutte anti-acridienne développée au Mali considère la formation des Brigades Villageoises comme un des supports essentiels qui doit aboutir à une lutte préventive plus efficace. Ce programme de formation des Brigades a donné de bons résultats après son démarrage il y a deux campagnes. Pour la campagne I990/9I il est prévu la mise en place de 600 Brrigades. Cette formation prévue pour début Mai sera également financée par le Projet MLI/86/009.

c)- Mise en place des produits et moyens d'Intervention :

Elle se fera sur la base des résultats de prospection des oothèques et des superficies agricoles à protéger. Il serait souhaitable que les besoins exprimés pour les deux phases de la campagne soient disponibles et mis en place avant le démarrage de la campagne compte tenu des difficultés de déplacement pendant la saison pluvieus Les fonds pour cette opération sont disponibles.

..../....-

Tableau n°1 : BESOINS DE LA PHASE I DE LUTTE CONTRE LES SAUTERIAUX/CAMPAGNE 1990/1991

RUBRIQUES	Besoin Total	DISPONIBLE		BESOINS A COUVRIR		OBSERVATIO
		Quantité	Source de Financemt.	Quantité	Coût en milliers de F.CFA	
I. PESTICIDE						Des action en cours p Gouvernemen pour l'acq tion de 10 tonnes
Poudre pour poudrage	700	267	USAID GVT	433 t	262 200	
Liquide (Fent 50 ULV ou équivalent	90.000 l	170 000 l	Stock Campagne 89/90	0	0	
II. EQUIPEMENT PAYSANS						
Sacs poudreurs	15.000	10.000	USAID CAMPAGNE 88/89	5.000	1.375	
Pulvérisat. Manuels Conventionnels	3.500	1.360	C.E.E.	2.140	85.600	
Pulvérisat. ULV	3.500	1.000	FRANCE	2.500	50.000	
III. MAINTENANCE						
Pièces de rechange	40.000 Stock entamé Camp. 1988/89 et 1989/1990	15.000	G V T		25.000	
IV. CARBURANT ET LUBRIFIANT						
Gaz - Oil	100.000	100.000	ALGERIE	0	0	
Essence	25.000	10.000	G V T	15.000	4.500	
Avgaz	40.000	40.000	G V T	0	0	
Lubrifiant	10.000	10.000	B A D	0	0	
V. MATERIEL DE PROTECT. ET DE CAMPEMENT						
Lits de Camp, Tentes	0		F A O G T Z MLI/86/009 C E E			
Combinaisons, Masques, Gants	6.000	1.500	GTZ - CEE FAO/MLI/86 009	4.500	22.500	
VI. PERDIEM EQUIPES						
Prospect. Techn.					15.000	
Personnel Saisonnier		2.500	B A D		0	
HEURES DE VOL	300	0		300	105.000	
VII. FORMATION Pilotes et Mécanicion Avion					35.000	
VIII. EXPERTISE	P.M.					
T O T A L					606.175	

Le tableau N°2 résume l'ensemble des besoins pour cette phase.

Tableau N°2 : BESOINS DE LA PHASE II CAMPAGNE 1990/1991

RUBRIQUES	BESOINS	COUT X 1.000 FCFA	OBSERVATIONS
PESTICIDES			
Malathion 96 % ULV	12 000	180 000	80.000 l dispo
Karaté (Lamdacyalotrine)	100 000	447 500	bles à la fin
			la première phe
FONCTIONNEMENT			dont 52.000 st
Perdiem équipes		15 000	dans l'aire gr
Gaz - Oil	Disponible		rigène du CP
Essence Ordinaire	15 000	4 500	
AVGAZ	40 000	Disponible	
JET A1	120 000	24 000	
EXPERTISE	P M	P M	
HEURES DE VOL			
Hélicoptères	600	210 000	
Avions à ailes fixes	400	P M	
TOTAL		881 000	

..../....-

111

- AUTRES RAVAGEURS -

Au cours de la campagne des programmes de lutte contre les oiseaux granivores, les rongeurs et les ravageurs des cultures maraîchères seront exécutés. Les besoins sont exprimés comme suit :

Oiseaux Granivores :

Objectifs de traitement : 5 000 ha

Produit : Fenthion I.000 à la dose de 3 Kg/ha.

Coût du Programme en milliers de F.CFA

15.000 l de Fenthion I.000 g/l :.....	75 000
100 Heures de vol :.....	35 000
15.000 l carburant avion :.....	3 000
Frais opérationnel :.....	2 500
TOTAL :.....	115.500

Rongeurs :

Objectifs de traitement IO.000 ha

Coût en milliers de F.CFA :

3.000 l de chlorophacinone :.....	15.000
100 T Suppert (Riz) :.....	Disponible
Frais opérationnel :.....	2 500
TOTAL :.....	17 500

Par ailleurs des battues seront organisées dans les zones à forte densité de populations.

CULTURES MARAICHERES -

Objectifs de traitement 2.500 ha

Coût en milliers de F.CFA :

6 000 l de Malathion 50% CE :.....	12 000
Dimethoalte C.E. 40% :.....	12 000
3 000 l de Karaté CE :.....	13 500
Pulvérisateurs conventionnels :.....	Disponibles
TOTAL :.....	37 500

..../....-

VII. AUTRES BESOINS :

Magasin de 200 m2 à Bamako :.....	30.000
I.000 fûts vides en acier pour le reconditionnement des vieux stock en attendant leur destruction :.....	20.000
T O T A L :.....	50.000

- RECAPITULATION DES BESOINS -

Lutte Anti-acridienne :

Sautériaux :

Phase I :.....	606.175
Phase II :.....	881.000
Criquet Pèlerin :.....	6.260

Autres Ravageurs :

Oiseaux Granivores :.....	115.500
Rongeurs :.....	17.500
Cultures Maraîchères :.....	37.500
Autres Besoins :.....	50.000
TOTAL GENERAL :.....	1.713.935

Appendix D.5. Risks and Costs of Intervention in the 1985 Campaign

1.1 Human Health Risks.

A representative evaluation of health risks during the 1985 campaign (MASI 1986) (see Section 7.0) showed that health risks occurred in two chief ways:

a. Risks of poisoning. Cases of acute intoxication of exposed people, with or without mortality, were recorded after pesticide treatments, among crop protection agents, farmers, and villagers.

Among the products used, dieldrin is extremely toxic and persistent and is not used on crops in most industrialized countries. Early in the campaign (1986), dieldrin was still occasionally used, sometimes in conjunction with fenitrothion, which was considered to result in long-term effectiveness. This mixture poses dangers for the public, especially due to the degradation products. The 1985 campaign began in the zones of Kayes and Yelimane, and despite safety measures, people and animals were not protected from insecticide droplets sprayed with ULV equipment. If treatment operations with this mixture had continued, it is feared that chronic poisoning would have occurred due to the cumulative effect of dieldrin.

The use of dusts and powders is often associated with careless safety practices. Least toxic compounds should be promoted over others, such as carbaryl dust over propoxur. Likewise, with the introduction of concentrated ULV formulations and hand-held ULV applicators for use by farmers, the risks of intoxication are increased.

b. Residues on food crops. The presence of high percentages of pesticide residues on treated grains have been demonstrated, which surpass the level of the Maximum Residue Tolerance Limit (LMR) (see Section 5). Residue analyses should be done after the campaigns for all products used, to verify that the residue levels do not surpass the LMR levels. The post-harvest interval must be respected as a safety measure, but this is unfortunately difficult to implement in Mali.

1.2 Costs of Environmental Impacts

Environmental monitoring is essential. While insufficient specific information is available on the short-term versus long-term impacts and potential impacts of pesticides on vulnerable resources in the Sahel, available studies show there is ample reason to continue monitoring the impact of Desert locust and grasshopper control over the longer-term. Studies carried out during the last few years (e.g., FAO in Senegal 1989, University of Oslo in Mali 1988 and 1989, Dynamac in Sudan 1988 (USAID), suggest that even lower dose rates than used in normal control operations may still reduce certain groups of non-target arthropods. The impact of wide-spread spraying on non-target animals is a matter of considerable concern, not the least because it could well lead to disruptions in the balance of natural enemies which normally keep locusts and grasshoppers in check.

Assessing the costs of environmental degradation, and benefits of

mitigative actions, are areas which this SEA considers worth investigating, from an ethical perspective. It is understood also that costs are involved in instituting environmental protection measures, and that these costs, difficult to quantify, should be accepted as part of a properly conceived control campaign.

1.3 Operational Costs

Between 1985 and 1989, extraordinary sums were spent to save crops attacked by locusts in the Sahelian regions of Mali. The expense averaged 3 billion francs CFA per year for the following:

- Equipment: camping supplies, spray equipment, radio transmitters, vehicles for transport, surveillance and treatment, office supplies, aircraft, etc.
- fuel and oil;
- salaries and expenses for personnel: experts, seasonal workers, per diem;
- aircraft rental;
- short-term training.

In the final analysis, it is clear that it is difficult to gather and quantify all the costs of actions dealing with an emergency situation.

2.0 Benefits of Intervention

2.1 Averted Crop Loss

As discussed in Section 4.3.2 under Crop Loss Assessment, national level estimation of crop loss is subject to many uncertainties, but reasonable estimates range between 1.5% to 20 % of the millet crop. This is equivalent to about 0.9 billion to 12 billion FCFA ($U.S. 3.5 to 46 million, respectively). In 1985, grasshopper damage to millet and sorghum surpassed 25% in the Sahelian zone alone, between latitudes 13 deg 30 min. and 15 deg 30 min. (SNPV 1986; MASI 1985).

Thus, even on the national scale, during most of the years 1985-90, investments in intervention (averaging 3 billion FCFA since 1985) would seem to have been justified based on the losses (0.9 to 12 billion FCFA) which presumably would have occurred without protective treatment. Balancing the expenses of the areas treated with the value of the crops protected, the profitability of these operations from an economic viewpoint may not be as questionable as often assumed.

However, the attempt to quantify the value of the treatments versus their costs is complicated by a number of factors, for example: (1) the relative contribution of the various pests to crop loss is poorly documented and distinguished; (2) the role of pests is complicated by the wide variations in crop developmental stage in various regions of the country; (3) the impact of pests is difficult to separate out from the role of drought; and (4) the effectiveness of treatments, and their contribution to prevention of crop losses, is not well quantified -- usually only a fraction (at best 50 to 80 percent) of the total infested area can be treated. Further complicating

matters is the wide variability in crop yields in response to biotic and abiotic factors, and the difficulty in obtaining reliable crop production data.

2.2 Other Avoided Costs: Economic and Social

When one takes into account the social value of interventions, assuming that they do swing the balance of food security in favor of the preventing food shortages, thus (1) keeping the population in place and avoiding a rural exodus, and (2) avoiding costs of grain imports from other zones for a population with little income, an argument can be made that such operations can be justified because they promote social equilibrium. Finally, because most of the crops affected are subsistence crops, and thus do not enter the cash economy, it is doubtful whether the peasant farmers, on their own, will be able to afford to carry the costs of the crop protection, at least for the foreseeable future.

Appendix D.6. Background, structure and organigram of the Mali Crop Protection Service as of 1989 (in French).

1.1. Le Service National de la Protection des Végétaux

Au Mali, le premier service chargé de lutter contre les parasites des végétaux n'a officiellement vu le jour qu'en 1942 avec la création du "Bureau Antiacridien" qui devint en 1954-1955 le Service de Protection des Végétaux.

Depuis Juin 1975, le service qui était devenu une division de la Direction de l'Agriculture s'est vu rattaché à l'O.P.S.R. où il est devenu la "Section de Vulgarisation d'Intervention" qui ne se limite plus seulement à la defense des cultures au sens strict.

1.2. Présentation de l'O.P.S.R.

L'opération de Protection des Semences et Récoltes a été créée en Février 1974 avec financement du Fond Européen de Développement (F.E.D.) d'un montant de 582 Millions de francs maliens pour une durée de 3 ans et 6 mois.

Ce projet avait principalement pour but la diffusion rapide des pesticides destinés à la désinfection des semences et des récoltes ainsi que l'approvisionnement en acricides pour lutter contre les sauteriaux.

La mise en exécution de ce projet a permis de doter le Mali d'un service de protection plus structuré et d'une industrie destinée à couvrir les besoins en pesticides de l'agriculture malienne.

Ce service avait pour buts essentiels de:

- vulgariser les produits formulés et les résultats de recherches en matière de protection des végétaux;
- assurer l'enclavement;
- organiser les interventions phytosanitaires sur l'ensenble du pays.

1.3. La S.N.P.V. - Buts et Objectifs

Le 2 Avril 1987 sur décret n°100-PGRM, fixant l'organisation et le foctionnement du Service de Protection des Végétaux et sur l'Ordonnance n°87-PGRM, le Service National de la Protection des Végétaux (S.N.P.V.) a pour mission de:

- mettre en oeuvre le programme National de Protection des Végétaux et de Lutte contre les Maladies, Parasites et Déprédateurs des cultures, des récoltes et de la flore.
- l'organisation de la qualité et de la communication des informations en matière de protection des végétaux.

- contrôle de la qualité des produits phytosanitaires et de l'état de santé des végétaux et des produits en relation avec les services compétents à la matière.

- formation du Personnel d'encadrement rural des paysans en protection des végétaux.

1.4. Organisation

Le Service de la Protection des Végétaux est rattaché au Cabinet du Ministère de l'Agriculture, et a son siège à Bamako. Il comprend des divisions et des bases phytosanitaire dans les zones de reproduction.

Les Divisions

- La division surveillance, alerte et intervention,

- La division étude et contrôle phytosanitaire,

- La division approvisionnement logistique et maintenance,

- La division administrative et financière.

Bases Phytosanitaires

Les bases phytosanitaires sont chargées de:

- la surveillance permanente de l'évolution des maladies, parasites et déprédateurs des végétaux sur une zone géographique donnée.

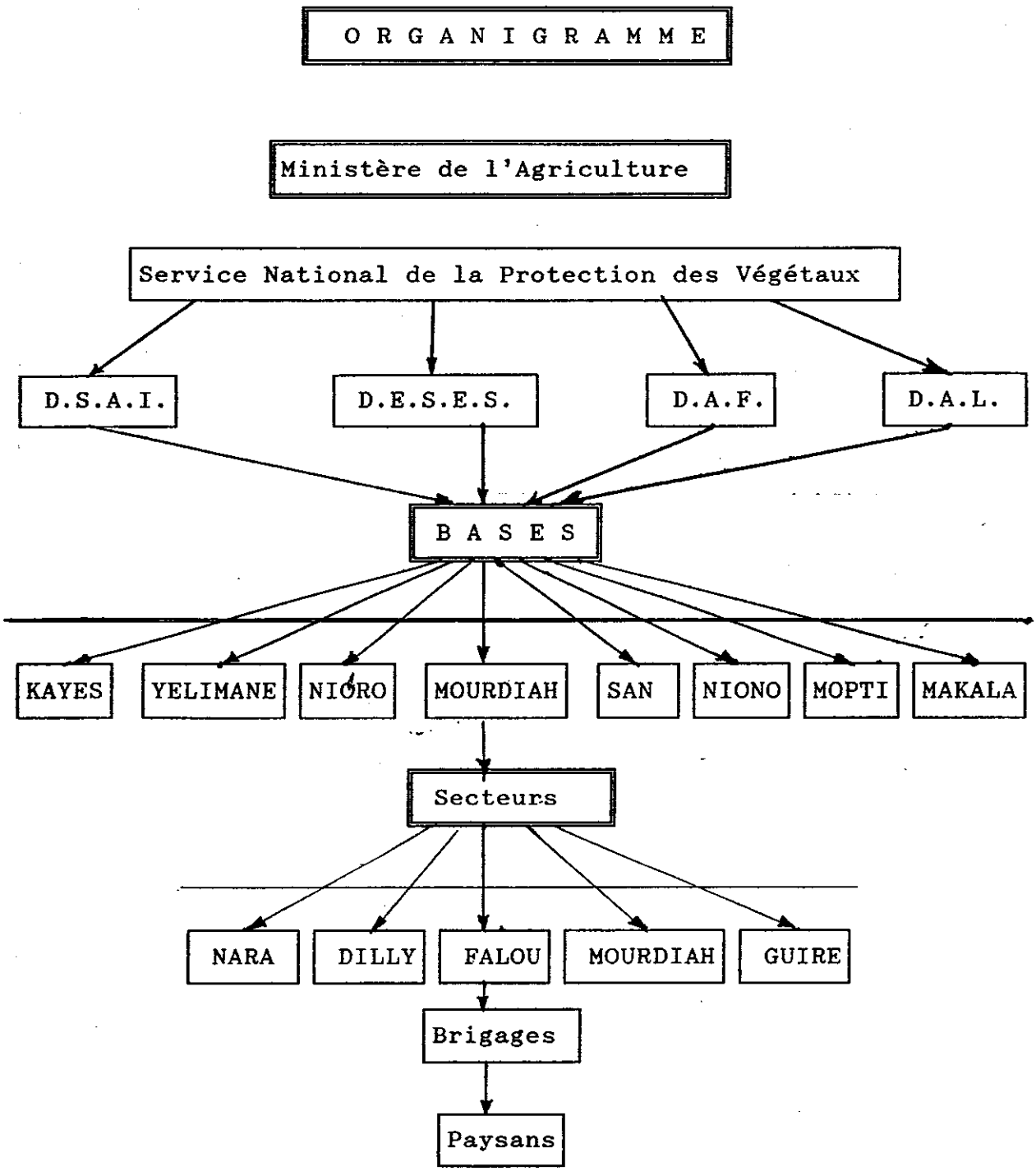
- l'alerte précose au niveau de la zone,

- la mise en oeuvre des programmes de lutte au niveau de la zone.

Chaque base phytosanitaire comprend plusieurs postes d'observation.

Les bases sont:

- Mourdiah
- Mopti
- San
- Yélimané
- Markala
- Nioro
- Kayes
- Niono.



* D.S.A.T. Division Surveillance, Alerte et Intervention.
* D.E.C.P. Division Etude et Contrôle Phytosanitaire.
* D.A.F. Division Administrative et Financière.
* D.A.L.M. Division Approvisonnement Logistique et Maintenance.

APPENDIX E

DOCUMENTS RELATED TO DISPOSAL OF OBSOLETE PESTICIDES IN MALI

E.1. Action Plan: Disposal of Obsolete Pesticides and Their Containers (in French). Developed at West African Regional Pesticide Disposal Conference, Niamey, Niger, Jan. 1990 (USAID 1991), together with the Delegates of Burkina Faso and Niger.

APPENDIX E. PLAN NATIONAL D'ACTION DU MALI

L'ELIMINATION DES EMBALLAGES DE PESTICIDES ET DES PESTICIDES OBSOLETES

Le Mali, le Niger, le Burkina-Faso se trouvent confrontés au problème de l'élimination des stocks obsolètes de Dieldrine 5% et 20% et d'autres produits ainsi que les emballages vides de pesticides.

Les trois pays conjointement proposent le plan d'action:

1. Pour les produits obsolètes:

   - Un système de stockage adéquat avec l'assistance des bailleurs de fonds;

   - l'installation ou l'utilisation de fours mobiles d'incinération;

   - une alternative d'expédition du produit au fabriquant ou au fournisseur pour leur destruction.

2. Pour les emballages vides:

   - la décontamination des fûts métalliques de 200 litres à 60 litres en vue d'une réutilisation éventuelle pour le reconditionnement de pesticides, d'autres produits ou à des fins contrôlées pour les services spécialisés. Exemple: balisage des pistes dans le désert, protection des arbres, etc...;

   - encourager la conception d'emballages moins attrayants et non réutilisables;

   - intensifier la sensibilisation en ce qui concerne l'élimination des petits contenants (écrasement et enfouissement dans le sol);

3. Besoin d'assistance technique et financière:

   - pour l'élaboration et la mise en oeuvre de réglementation phytosanitaire;

   - pour l'amélioration des conditions de stockage à court, moyen et long terme;

   - pour la création d'un réseau régional d'information proposée à Accra 1989 et les possibilités d'exploitation avec les autres réseaux existants;

   - pour la création d'un laboratoire régional d'analyses et de contrôle de qualité des pesticides ou du renforcement en matière d'équipement des

laboratoires nationaux;

- pour la recherche scientifique des produits phytosanitaires;
- pour des études de Recherche sur l'impact de l'utilisation des produits sur l'homme et sur l'environnement.

PROPOSITION

Aménagement des zones de stockage, le reconditionnement, de transport et des infrastructures de vieux stocks de produits dans un délai de 6 à 12 mois;

Acquisition de fours mobiles d'incinération dans un délai raisonnable.

APPENDIX F

SPECIES OF BIRDS IN MALI

F.1. Checklist of Birds in Mali, including key dietary, migratory and habitat data. Common names are given in French only.

Scientific Name	Diet[1]	Migration[2]	Popular Name	Habitat[3,4] S	Sv	H	G
Accipitridae							
Accipiter badius	i/r	A	Epervier Shrika	-	2	-	-
Aegypius tracheliothus	-	-	Oricou	-	2	-	-
Butastur rufipennis	i/r	A	Busard des Sauterelles	-	-	2	-
Melierax gabar	i/r	A	Vantour Gabar	-	2	2	-
Melierax metabates	i/r	A	Vantour Chanteur	-	2	-	-
Milvus parasitus	i/r	-	Milan Noir	1	1	3	3
Neophron monachus	i/r	-	Percnoptère Brun	-	1	1	1
Polemaetus bellicosus	r	?	Aigle Martial	-	2	-	-
Terathopius ecaudatus	r	?	Bateleur	1	1	-	-
Aquila rapax	r	E	Aigle Ravisseur	-	2	-	-
Alaudidae							
Eremopterix nigriceps	(i)	A	Alouette-moineau à front Blanc	-	-	3	2
Galerida cristata	(i)	A	Cochevis Hupé	-	-	1	3
Mirafra javanica	(i)	A	Alouette Chanteuse	-	-	-	2
Alcedinidae							
Ceryle rudis	-	E	Martin-pêcheur Pie	-	-	-	1
Halcyon leucocephala	i/r	A	Martin-Chasseur à Tête Grise	-	-	2	-
Anatidae							
Anas querquedula	-	E	Sarcella d'Eté	-	-	-	1
Plectropterus gambensis	-	A	Canard Armé	-	-	2	-
Sarkidiornis melanotos	-	A	Canard Casqué	-	-	-	1
Ardeidae							

Ardea melanoceophala	i/r	A	Héron Mélano-céphale	-	-	2	-
Ardeola ibis	i/r	E	Heron Garde-Boeufs	3	1	2	3
Ardeola ralloides	i/r	E/A	Héron Crabier	-	-	-	1
Butorides striatus	i/r	?	Héron à Dos Vert	-	-	-	1
Egretta alba	i/r	-	Grande Aigrette	-	-	2	1
Egretta garzetta	i/r	E	Aigrette Garzette	-	-	2	1
Ixobrychus sturmii	i/r	A	Blongios de Stu.rm	-	-	2	-
Bucerotidae							
Tockus erythrorhynchus	i/r	A	Petit Calao à Bec Rouge	3	1	2	-
Tockus nasutus	i/r	A	Petit Calao à Bec Noir	2	2	2	-
Burhinidae							
Burhinus capensis	i/r	A	Oedicnème de Cap	1	-	-	1
Burhinus senegalensis	i/r	A	Oedicnème du Sénégal	-	-	-	3
Capitonidae							
Lybius dubius	-	-	Barbican à Poitrine Rouge	-	2	-	-
Charadriidae							
Charadrius dubius	i	E/A	Petit Gravelot	-	-	-	1
Himantophus himantophus	i	-	Echasse Blanche	-	-	-	1
Tringa hypoleucos	i	E/A	Chevalier Guignette	-	-	-	3
Tringa ochropus	i	E/A	Chevalier Cul-blanc	-	-	-	3
Vannellus spinosus	i	A	Vanneau Armé	-	1	-	3
Vannellus tectus	i	A	Vanneau à Tête Noir	1	2	-	-
Ciconiidae							
Ciconia abdimii	i/r	A	Cigogne d'Abdim	2	2	2	2
Leptotilos crumeniferus	i/r	A	Marabout	-	-	2	-
Columbidae							
Streptopelia semitorquata	-	A	Tourterelle à Collier	-	-	2	-
Streptopelia senegalensis	-	A	Tourterelle Maillée	1	-	-	-
Streptopelia vinacea	-	A	Tourterelle Vineuse	3	3	3	-

Oena capensis	-	A	Tourterelle du Cap	1	1	3	-
Treron waalia	-	A	Pigeon à Epaulettes Violettes	1	-	-	-
Coradiidae							
Coracias abyssinica	i/r	A	Rollier d'Abyssinie	1	3	3	-
Eurystomus glaucurus	i/r	A	Rollier Africain	2	-	-	-
Corvidae							
Corvus albus	i	A	Corbeau Pie	-	1	3	2
Ptilostomus afer	i	A	Piac-Piac	-	-	3	-
Cuculidae							
Chrysococcyx klaas	i	A	Coucou de Klaas	-	2	-	-
Clamator levaillantii	i	A	Coucou de Levaillant	2	-	-	-
Dicruridae							
Dicrurus gdsimilis	i	?	Drongo Brillant	3	3	1	-
Emberizidae							
Emberiza tahapisi	-	A	Bruant Cannelle	-	-	2	-
Estrildidae							
Estrilda bengala	-	-	Gordon Bleu	-	3	2	2
Amidina fasciata	-	-	Cou-Coupé	-	1	-	-
Lonchura malabarica	-	-	Bec d'Argent	-	-	2	2
Lagonosticta senegala	-	-	Amarante Commun	-	-	-	2
Estrilda troglodytes	-	-	Bec de Corail Cendré	-	1	-	-
Falconidae							
Falco ardosiaceus	i/r	A	Faucon Ardoisé	2	-	2	-
Glareolidae							
Pluvianus aegyptius	i	A	Pluvian d'Egypte	-	-	-	1
Jacanidae							
Actophilornis africana	i	A	Jacana	-	-	-	3

Laniidae							
Corvinella corvina	i/r	A	Corvinelle	1	-	-	-
Lanius senator	i/r	E	Pie-grièche à Tête Rousse	1	3	2	-
Tchagra senegale	i/r	A	Téléphone Tchagra	-	1	-	-
Laridae							
Sterna albifrons	-	E/A	Sterne Naina	-	-	-	1
Sterna leucoptera	-	E/A	Guifette Leucoptère	-	-	-	2
Meropidae							
Merops albicollis	i	A	Guèpier à Gorge Blanche	2	-	2	-
Merops nubicus	i	A	Guèpier Ecarlate	2	2	2	-
Merops orientalis	i	A	Petit Guèpier Vert	3	3	-	3
Muscicapidae							
Bradornis pallidus	i	-	Gobe-mouches Pâle	-	-	1	-
Motacillidae							
Motacilla alba	i	E/A	Bergeronnette Grise	-	-	-	1
Motacilla flava	i	E/A	Bergeronnette Printanière	-	-	-	1
Musophagidae							
Crinifer piscator	-	-	Tourace Gris	1	-	-	-
Nectarinidae							
Antrhreptos platura	-	-	Petit Soui-manga à Longue Queue	1	-	-	-
Nectarinia pulchella	-	A	Soui-manga à Longue Queue	1	2	-	-
Nectarinia coccinigaster	-	A	Soui-manga Eclatant	-	2	-	-
Nectarinia senegalensis	-	A	Soui-manga à Poitrine rouge	1	-	-	-
Phalacrocoracidae							
Phalacrocorax africanus	-	A	Cormoran Africain	-	-	-	1

Picidae							
Campethera punctuligera	i	-	Pic à Tâches Noires	-	2	-	-
Mesopicos goertae	i	-	Pic à Gris	-	3	-	-
Ploceidae							
Euplectes afer	-	A	Vorabé	-	-	2	2
Euplectes hordeaceus	-	A	Monseigneur	2	-	2	2
Ploceus cucullatus	-	A	Tisserin Gendarme	-	2	2	2
Passer luteus	-	A	Moineau Doré	-	-	-	1
Ploceus velatus	-	A	Tisserin à Tête Rousse	2	2	2	2
Ploceus melanocephalus	-	-	Tisserin à Tête Noire	-	-	-	1
Sporopipes frontalis	-	A	Moineau Quadrillé	-	3	-	-
Quelea quelea	-	A	Travailleur à Bec Rouge	-	-	-	1
Vidua macroura	-	-	Veuve Dominicaine	2	-	-	-
Vidua chalybeata	-	-	Combassou du Sénégal	-	-	-	2
Passer griseus	-	-	Moineau Gris	2	2	2	2
Psittacidae							
Poicephalus senegalus	-	A	Youyou	1	-	-	-
Psittacula krameri	-	-	Peruche à Collier	1	3	-	-
Pychonotidae							
Pychonotus barbatus	i	-	Bulbul Commun	3	-	-	-
Rallidae							
Porphyrio porphyrio	i	A	Poule Sultane	-	-	-	1
Scopidae							
Scopus umbretta	i	A	Ombrette	-	-	-	1
Sturnidae							
Lamprotonis caudatus	i	-	Merle Métallique à Longue Queue	3	3	2	2

Lamprotonis purpureus	i	-	Merle Métallique Pourpé	2	1	2	-
Spreo pulcher	i	A	Etourneaux à Ventre Roux	-	1	2	-
Sylviidae							
Hippolais pallida	i	E	Hypolais Pâle	-	1	-	2
Phylloscopus trochilus	i	E	Pouillot Fitis	-	1	1	1
Sylvietta brachyura	i	A	Fauvette Crombec	-	2	-	-
Threskiornithidae							
Plegadis falcinellus	i	E/A	Ibis Falcinelle	-	-	2	1
Threskiornis aethiopica	i	A	Ibis Sacré	-	-	2	-
Turdidae							
Cercotrichas podobe	i	-	Merle Podobé	-	2	-	-
Oenanthe bottae	i	A	Traquette à Poitrine Rousse	-	1	-	-
Oenanthe oenanthe	i	A	Traquette Motteux1	-	-	-	-
Phoenicurus phenicurus	i	E	Rouge-queue à Front Blanc	-	1	-	-
Upupidae							
Upapa epops	i	E/A	Huppe Fasciée	-	3	2	-
Phoeniculus purpureus	i	A	Moqueur	-	2	2	-
Total no. species in dry season				24	28	11	32
Total no. species in rainy season				19	30	41	26

FOOTNOTES ([1,2,3,4])

EXPLANATION OF LEGEND OF APPENDIX F:

[1]) i = insectivorous
r = raptor - predatory
- = other

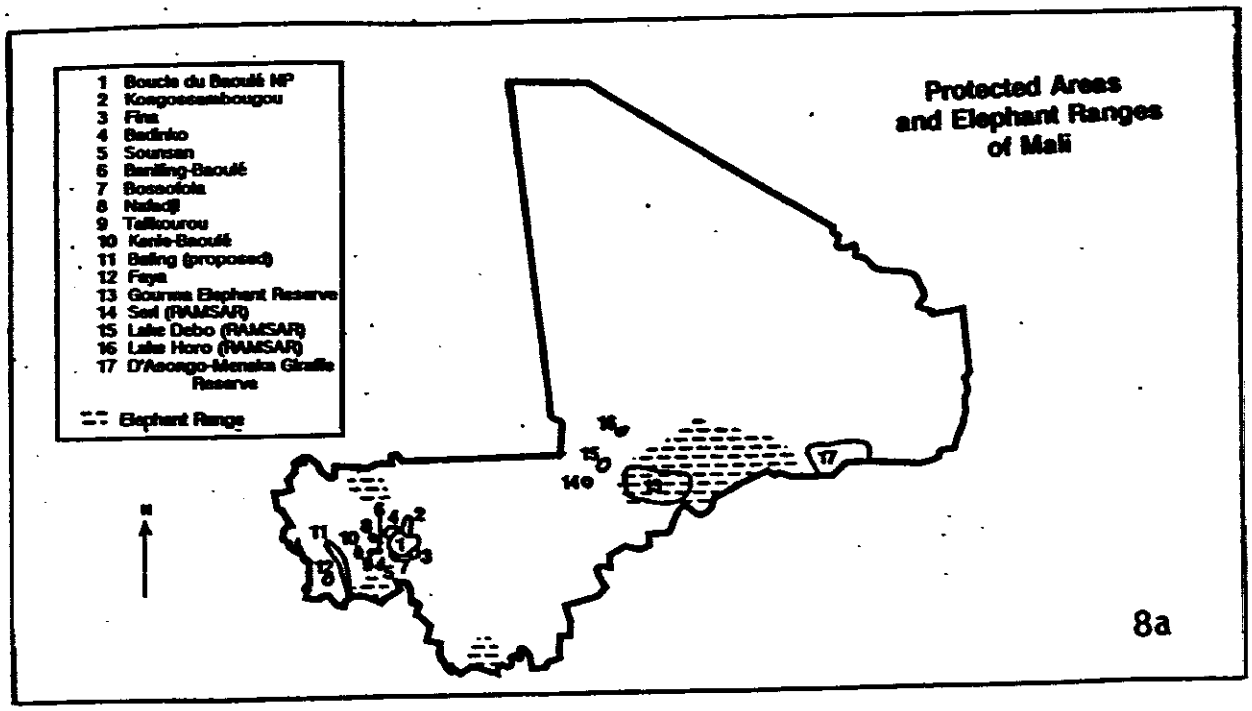
[2]) A = intra-African migrator
E = Eurasien migrator
- = non-migratory
? = migratory behavior unknown

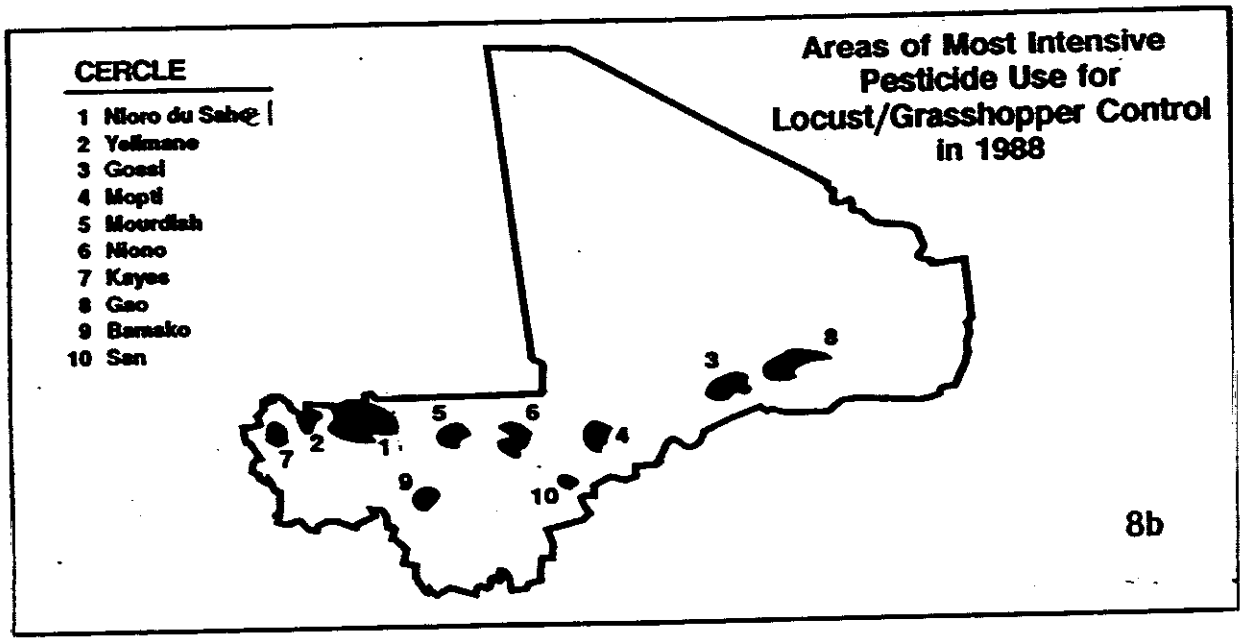
[3]) S = Ségou
Sv= Sévaré
H = Hombori
G = Gao

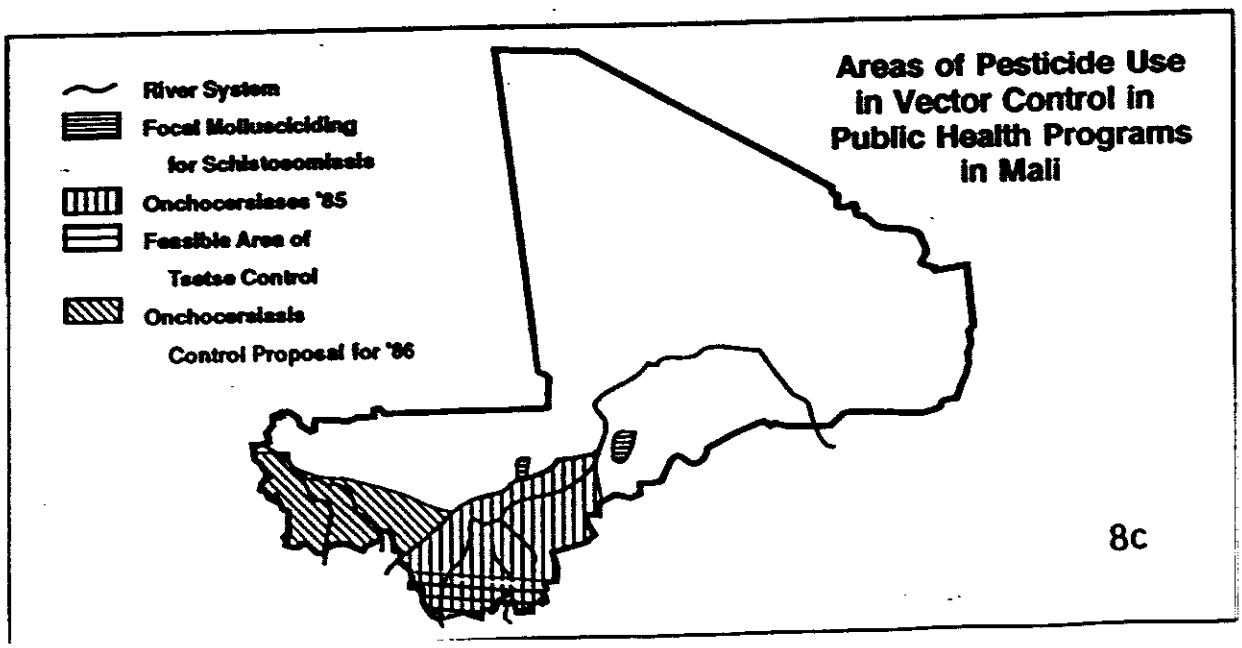
[4]) 1 = observed during dry season
2 = observed during the rainy season
3 = observed during both seasons

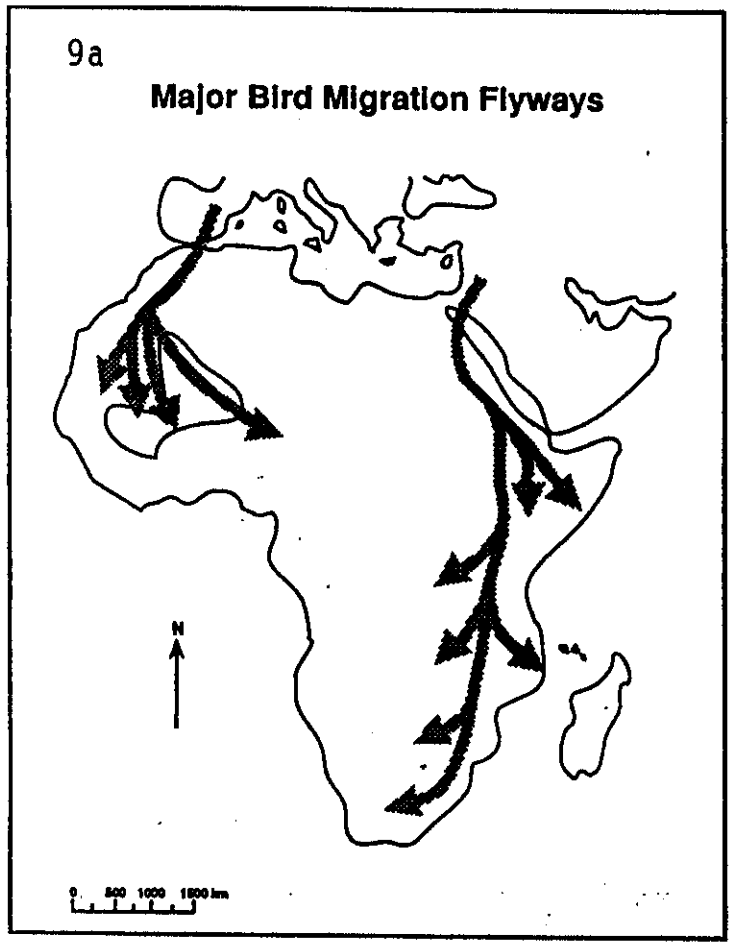
Figure 8. Protected Areas in relation to Areas of Particular Pesticide Use in Mali (compiled from Peckham 1991).

a. Protected Areas and Elephant Ranges.
b. Cercles in which Locust and Grasshopper Control Activities was Greatest in 1988.
c. Areas of Pesticide Use for Vector Control in Human Health Programs.


Protected Areas and Elephant Ranges of Mali
1 Boucle du Baoulé NP
2 Kongoussambougou
3 Fina
4 Badinko
5 Sounsan
6 Bamling-Baoulé
7 Bossofola
8 Nafadji
9 Tafilourou
10 Kanie-Baoulé
11 Baling (proposed)
12 Faya
13 Gourma Elephant Reserve
14 Sail (RAMSAR)
15 Lake Debo (RAMSAR)
16 Lake Horo (RAMSAR)
17 D'Aoongo-Menaka Giraffe Reserve
Elephant Range
N
8a


Areas of Most Intensive Pesticide Use for Locust/Grasshopper Control in 1988
CERCLE
1 Nioro du Sahel
2 Yelimane
3 Goesi
4 Mopti
5 Mourdiah
6 Niono
7 Kayes
8 Gao
9 Bamako
10 San
8b


Areas of Pesticide Use in Vector Control in Public Health Programs in Mali
River System
Focal Molluscicidng for Schistosomiasis
Onchocersiases '85
Feasible Area of Tsetse Control
Onchocersiasis Control Proposal for '86
8c



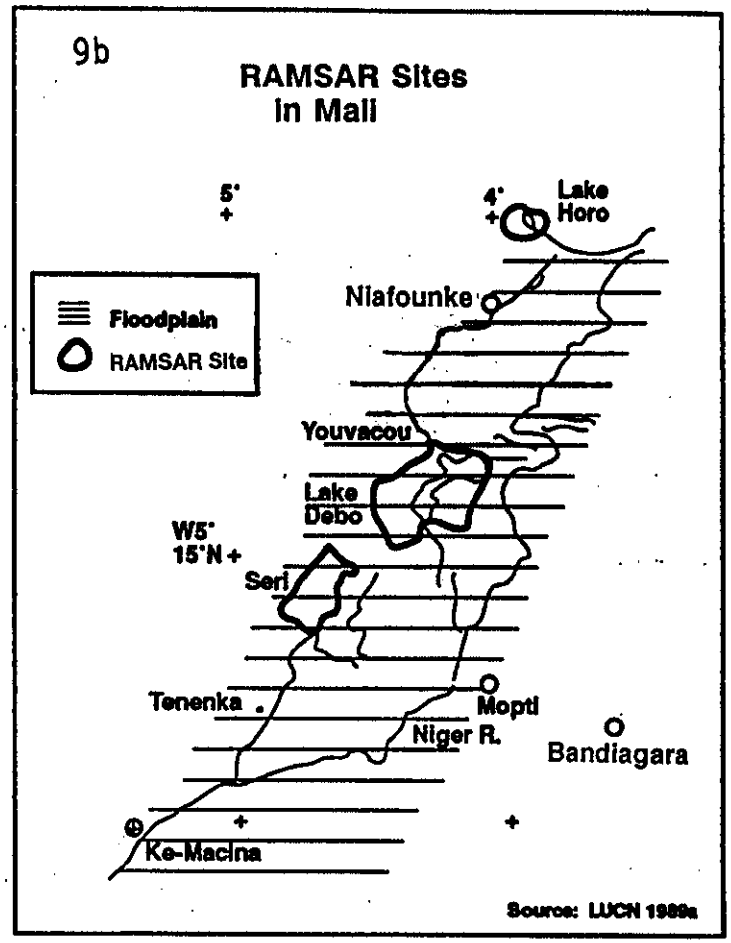


Figure 9. Representative Biological Resources at Risk:

a. Major Migratory Flyways for Eurasian Birds into Africa.
b. RAMSAR Convention-designated Wetland Sites of Biological Significance in the Mali Interior Delta.

8.5 Ecotoxicological Studies

In recent years, large areas have been sprayed with pesticides for grasshopper and locust control, especially in the Sahelian/Sudanian belt of Africa. Grasshopper campaign predictions for 1990 in the Sahel and Sudan alone foresaw treatment of a record 6.5 million hectares, based on the pattern of the 1989 season, although the actual hectarage treated in 1990 amounted to less than 30% of this number (OCLALAV 1991). This pattern of large-scale treatments has caused considerable concern with regard to their potential impact on non-target organisms. The supplemental environmental assessments (SEA's) for locust/grasshopper control -- under development in eight sub-Saharan nations -- emphasize, and seek to develop guidance for, minimizing pesticide use to mitigate environmental impacts.

While non-persistent pesticides are likely to remain an indispensable tool for effective control of acridids, ever-increasing emphasis is being placed upon developing the means to reduce their application to the absolute minimum. This is attempted through improved early warning, survey and monitoring, traditional and/or innovative preventive measures (e.g., digging up egg pods, early season control of nymphs), improved application technologies, tactical and strategic control strategies, rational and safe pesticide use and distribution plans, alternative non-conventional control measures (e.g., biopesticides, growth regulators), and the like. In view of the fact that pesticides will be an unavoidable component of the grasshopper and locust management picture in the foreseeable future, efforts are being mounted from several sides to assess the environmental impact of these chemical treatments.

Under the aegis of USAID, the Crop Protection Service, USDA and FAO, several studies have been done in Mali on the impact of pesticides on the environment. Accordingly, in 1981, an ecological mission was conducted during two time periods (February-March and August-September), to study the environmental impact of pesticide treatments in the Sahel region between Gao and Bamako (Everts et al., 1981).

In 1985, a USAID consultant, while evaluating the locust and avian situation in Mali and the merits of the control techniques implemented, evaluated at the same time the impact of pesticides on man and the environment. His report recommended ecological studies to better define the role of natural enemies and the impact that pesticides have on their populations.

In 1987, at the request of USAID, a large-scale experimental program on use of pesticides against acridids was conducted by the American firm Dynamac, Inc. and the National Crop Protection Service (Dynamac 1988). These trials included efficacy tests of 8 pesticides (carbamates, organophosphates and pyrethroids) and their impact on the sahelian environment (man, mammals, birds, non-target insects, pasture, crops, seeds, etc.). The trials were conducted and followed by a multi-disciplinary team composed of biologists, toxicologists, agronomists, crop protection specialists, doctors, veterinarians, etc., in order to study all aspects of pesticide use in the

environment.

These activities demonstrate the determination and concern of the government authorities, international organizations and bilateral cooperation organizations to assure good pesticide management and to safeguard the Malian environment.

Probably the most comprehensive and large-scale ecotoxicological study involving grasshopper and locust control pesticides undertaken to date, was the pilot study undertaken by the FAO in Senegal in 1989, involving an international team of researcher. The insights gained from this study merit special attention, and are discussed in the following section.

8.5.1 Environmental Impact of Locust and Grasshopper Control Pesticides

From June to October 1989, a pilot study was carried out in the savannah of northern Senegal, under the auspices of the FAO, to assess the impact of desert locust control pesticides might have on the environment. Scientists from Senegal (University of Dakar), The Netherlands (Wageningen Agricultural University, the United Kingdom (NRI), the United States of America (USDA-APHIS, Denver Wildlife Research Center) and France (PRIFAS) participated in the project, which was funded to a large extent by the government of the Netherlands (Everts 1990a, b; Keith and Mullie 1989). A follow-up three-year study was initiated in Senegal during the first helf of 1991.

Fenitrothion, chlorpyrifos and diflubenzuron were sprayed on experimental plots 6 km-square in size, to assess the pesticides' impact on a variety of organisms such as birds, aquatic invertebrates, fish, beneficial arthropods, grasshoppers,and soil micro-organisms. The pesticides were applied at rates used in desert locust control and at roughly double those rates to assess the risk of "over-application" (fenitrothion at 485 and 825 g a.i./ha; chlorpyrifos at 270 and 390 g a.i./ha; diflubenzuron at 40 and 85 g a.i./ha).

8.5.2 Differential impacts of grasshopper vs. locust control

Grasshopper control differs from desert locust control in some essential aspects which are important as far as potential environmental impact is concerned:

a. Treatments are more often carried out in cultivated areas. This means that mortality in non-target arthropods is more likely to include natural enemies of important crop pests, and possibly could cause outbreaks of secondary pests.

b. Natural enemies are thought to have a more important role in regulating mainly sedentary grasshopper populations than those of the Desert locust, which are highly mobile. Egg mortality of 40-80 percent in the relatively mobile Oedaleus senegalensis appears to be more the rule than the exception, and there is no reason to expect egg mortality in truly sedentary grasshoppers to be less (Popov et al. 1990). The contribution of natural enemies to larval mortality of grasshoppers is less well-

known. However, this "unexplained" hopper mortality maybe very high indeed (e.g., up to 80 percent in Red locust) and natural enemies probably play an important role at least under certain circumstances. Grasshopper control may thus cause resurgences of the grasshopper populations themselves.

c. Grasshopper control late in the season (especially of O. senegalensis) has in the recent past been carried out over very large, almost continuous, areas. This means that any non-target populations which depend on dispersal from untreated areas to restore their populations, will have increasing difficulties recovering from pesticide effects with increasing block sizes, if their numbers are decimated by the treatment. This is even more the case for the less mobile species. Treatment of blocks of several thousands or even hundreds of thousands of hectares, as has happened in the past, are bound to seriously hamper population recovery of many groups of non-target organisms.

d. It is not unusual in grasshopper control for the same area to be treated twice or even three times in the same season; in desert locust control, an area is seldom re-sprayed. Repeated treatments in the relatively short Sahelian growing season may reduce the speed of recovery of affected non-target organisms considerably or even eliminate them for A substantial period.

e. Grasshopper control may be less harmful than Desert locust control in the sense that often lower dose rates are required (e.g., treatments against predominately O. senegalensis). However, mixed populations of grasshoppers may well contain species which are at least as resistant to pesticides as desert locusts (e.g., Kraussaria angulifera, Acorypha glaucopsis, Cataloipus cymbiferus); if high levels of control of these populations are aimed for, pesticide dose rates will be elevated. On the other hand, knowledge of the particular ecological and behavioral attributes of the grasshopper species may assist in devising control strategies. For example, C. simulatrix is known to retreat to cracks in the clay of depressions and other areas periodically wet. Baits may be particularly effective in this situation.

Furthermore, grasshopper habitats in the Sahel may be less vulnerable to pesticides than the isolated Desert Locust habitats like Wadi's and valleys in the more arid zones because speed of recovery of treated populations will be slower, although this is not much more than an educated guess. On the other hand, grasshopper control has more chance of being carried out in or near very vulnerable aquatic habitats (e.g., Niger River Interior Delta, Mali, or the Sine-Saloum estuary, Senegal). However, at least an informal policy appears to be maintained in the Sahel of avoiding treatment near wetlands.

8.5.3 Side-effects Demonstrated in Senegal Study

Birds. In plots sprayed with fenitrothion, significant reductions of bird densities were found, probably largely caused by movement out of the plot through food depletion. Direct mortality -- up to 10 percent of the bird population -- may have occurred in"double dose" organophosphate plots, based

on carcass searches. Cholinesterase analysis of brains of dead birds showed that mortality was caused by the pesticides. Reduced reproductive success, as reflected in large numbers of debilitated lark fledglings, was the most serious impact identified, as it has the greatest potential for long-term effects on bird populations.

Aquatic Life. Both fenitrothion and chlorpyrifos at recommended dose-rates eradicated local shrimp populations in the study lakes. Chlorpyrifos caused considerable mortality in one small fish species, *Gobius* sp. Diflubenzuron was not found to affect aquatic macro-invertebrates or fish.

Beneficial arthropods. Large initial mortality was observed in many groups of beneficial arthropods after treatments with the two organophosphates. In many cases, recovery was observed within two weeks after spraying. However, groups which were significantly reduced (i.e., more than 50 %) over longer periods were found in such important groups of beneficials as carabid beetles (chlorpyrifos single dose), tenebrionid beetles (fenitrothion single dose), Ichneumonidae (parasitic wasps) (fenitrothion double dose and diflubenzuron single dose), Braconidae and Tiphiidae (parasitic wasps) (fenitrothion single dose), and Asilidae (predatory flies) (fenitrothion single dose).

Microbial activity. No large changes were found in several microbial processes related to nutrient cycles in the soil.

Although the overall environmental impact observed was considered to be limited, the study showed there is ample reason to continue monitoring the impact of Desert locust and grasshopper control over the longer-term. Also, other studies carried out during the last few years (e.g., University of Oslo in Mali 1988 and 1989, Dynamac in Sudan 1988 (USAID), suggest that lower dose rates than used in the Senegal trials may still reduce certain groups of non-target arthropods considerably. Often, recovery was seen in the second week after treatment.

8.5.4 Follow-up Environmental Impact Studies

Based on the Senegal pilot study and results from the above-mentioned studies, a FAO follow-up project, termed "Locustox", was launched in mid-1991 to concentrate on questions regarding the following: (a) further screening of different locust pesticides for effects on relevant African non-target organisms; (b) factors influencing recovery of treated populations (e.g., size of treated areas); (c) the development of laboratory and field methods, relevant to Africa, of monitoring impacts and side-effects.

The project will be based in Senegal, but is expected to have major activities in other countries as well. It contains an important training component for counterpart scientists, since this type of research is relatively new. Although directed primarily at determining environmental

impact with chemicals that would be applied to Desert Locust control[1], the project will assess some aspects of grasshopper control as well, in view of the latter's prevalence and potential impact on the environment.

Several other countries/institutions plan or are conducting activities in the field of environmental impact of locust or grasshopper control:

a. USAID/Morocco, with the Denver Wildlife Research Center and the Moroccan Plant Protection Service, is carrying out a long-term training and research program on environmental assessment and ecotoxicology in Morocco.

b. The University of Oslo/Agricultural University of Norway may carry out further trials in Mali;

c. PRIFAS plans to carry out impact assessments in Chad;

d. GTZ has conducted environmental assessments in Niger, in 1990;

e. A.I.D. Africa Bureau may consider co-support of a proposed parallel study to the Senegal one (Locustox), concentrating on impacts on wild vertebrate animals (Mali could be a key country involved).

It is expected that these groups will seek to coordinate activities. One of the tasks of the FAO projects will be to improve information exchange and coordination among those involved in this area of inquiry.

---

[1] It is recognized that Senegal has no recession populations or habitats of Desert locust, but the techniques and dosages used will be developed according to the requirements of Desert locust control, as they were for the pilot study (Keith 1990).

9.0 SUMMARY OF FINDINGS, RECOMMENDATIONS AND OPTIONS

Grasshopper outbreaks such as those of the past five years are a chronic but fluctuating problem in Mali. The locust plague of 1987-8 required significant emergency assistance from international organizations and donors such as USAID. In all, over $ 5 million have been spent over the past five years by the U.S. government in the Mali grasshopper and locust control program. Clearly, support at such levels cannot continue in the long-term. Nor can the situation be dealt with in the mid- to long-term problem without formulating and implementing some well-planned programs.

The social and economic value of such programs for the people and the government of Mali remains relatively unquestioned. It would be useful to measure the scope and the necessity of such programs as an element of any strategies and alternatives which might be developed.

The more important of the country-specific priorities are covered below in the context of conditions in Mali. A point-by-point summary of the relation of recommendations in the PEA to the recommendations in this SEA is given in Appendix B.

9.1 Monitoring: Human Health, Environmental, Treatment Efficacy, Pesticide Quality

Finding: **Applicator exposure:** Monitoring cholinesterase inhibition of CPS applicators and periodic testing of long-term users has preventive value. In every case, it is essential to conduct baseline testing in order to correctly interpret the results of cholinesterase tests. Testing of the general population, by contrast, is considered of much less value since exposure of the general population is expected to be minimal and random cholinesterase levels measured in a human population are too variable to be of very much value. Similarly, controlled-case epidemiological studies are expected to have confounding factors such that pesticide effects, if any, would be masked. The latter type of study is not recommended.

Recommendation(s): Cholinesterase should be monitored among treatment crew members, and other high exposure individuals, such as formulation factory workers. Individuals showing significant inhibition should be removed from further exposure (see section 7.5). Studies should be supported on the impact of pesticides on man in the zones where pesticides are periodically used in large quantities. This could be done by monitoring cholinesterase levels on crop protection personnel, and farmers in the zones of Yelimane, Kayes, Nioro, Nara, and also in the CMDT zone, where large quantities of pesticide products are used on cotton.

Finding: **Residue monitoring:** In areas of extensive pesticide use, environmental samples analyzed for residues would be a valuable basis for exposure assessments.

Recommendation(s): Residue-based exposure assessment should be used in refining and designing future pesticide activities. Evaluation of residues requires the collaboration of the CPS, SMPC, and the INRSP (National Institute of Research in Public Health) Toxicology Laboratory in Bamako. Reinforce the technical capacity in Mali for residue analyses, so that the analyses can be brought to bear on future applications of pesticides,

providing a measure of security and the capacity to test for levels of residues (see sections 5.3, 6.1.3, 7.5 and 8.3).

Finding: **Environmental monitoring:** The monitoring of the effects of pesticide use on non-target species and the environment can be a valuable means of detecting possible misuse or unexpected adverse effects.

Recommendation(s): Environmental monitoring should be included as an integral part of any pesticide use program. Monitoring results should be used in the planning and operational phases of locust and grasshopper control programs to adjust or curtail environmentally damaging operations (see section 8.3, 8.5).

Finding: **Treatment efficacy:** Little or no evaluation of the efficacy of pesticide treatments is conducted during and following control operations (Sect. 5.1.3).

Recommendation(s): An appropriately experienced person from the CPS should be designated to conduct spot-checks specifically to evaluate the efficacy of treatments and methods used by applicators. Evaluation of effectiveness and impact of control treatments is a necessary and instructive tool for the continual improvement of control operations. Likewise, such evaluation is consistent with the need to determine the cost-effectiveness of operations, and with the need, expressed increasingly by donors, to verify and document impacts of interventions.

Finding: **Pesticide quality:** Little or no capacity exists in Mali for the independent evaluation of the quality of pesticide products and formulations used and stored in Mali.

Recommendation(s): An initiative should be undertaken to identify the appropriate means and site for a modest pesticide quality control laboratory in Mali, which would allow independent verification of the active ingredients of pesticide products imported into or formulated and repackaged in Mali. It would also allow the condition of stored pesticides to be monitored as to possible loss of active ingredient through poor storage conditions (Sect. 6.3).

9.2 Legislation, Policy and Safety

Finding: A good foundation will exist in pesticide regulation by the GRM/CPS for directing the safe use of pesticides, if currently drafted legislation is passed.

Recommendation(s): Pesticide management legislation must be strengthened, and implementation of that legislation should include improvement of the labelling of pesticides, providing clear precautionary statements for avoiding both adverse human and environmental effects, specific use directions, and appropriate directions for disposal/recycling of empty containers, and improvement in the management of pesticide stocks (see sections 3.2, 6.3). When pesticide and toxic substances legislation is enacted, it is probable that GRM will benefit from technical assistance in connection with implementation. USAID could support the provision of appropriate outside expertise to assist the GRM to become self-sufficient in pesticide regulation.

Finding: The CPS shows concern for the safety of the general population and pesticide applicators, but the human health aspects of pesticide use in Mali could be strengthened. By further strengthening the applicators' knowledge and understanding of safety procedures, especially of supervisors, exposure and therefore risk to the general population are expected to be negligible. Mali has an extensive health services training program that could be used as a complement to the CPS training program.

Recommendation(s): The present system of pesticide applicator training and education should continue and be improved to ensure proper and safe pesticide application. Each applicator crew should be independent in ability to handle any cases of poisoning that occur, including administration of antidote and removal from exposure of any worker showing symptoms (see section 7.1). The Ministry of Health and CPS should work cooperatively on the delivery of training in the safe use of pesticides, the recognition of symptoms of pesticide poisonings, and the treatment of pesticide poisonings. This collaboration would occur during control campaigns, so as to raise the awareness of the populace, and to provide for surveillance before and after.

Finding: Traditionally, the CPS has applied little pesticide in the Niger Inland Delta or in national parks. These areas are generally richer in wildlife than other areas. The Niger Inland Delta is especially vulnerable due to high fish productivity and populations of waterfowl of international interest. It should be noted also that treatment of infestations grain-eating birds is becoming an increasing need in these areas (Sect. 5.3), and therefore represents a greater potential hazard.

Recommendation(s): Regulations should be developed which formally restrict or forbid the treatment of locusts or grasshoppers in the Niger Inland Delta and in the national parks (see section 8.3). A map showing distribution of the principal acridid species, other major insect pests, and granivorous birds, in relation to the reserves and other areas to be protected in Mali, would be a very useful contribution to the environmental protection of Mali with respect to decision-making for treatments against acridid and other pests. The production of such a map (see section 8.3.1) is recommended.

Finding: The regions adjacent to environmentally sensitive areas can be a source of impact in the protected area.

Recommendation(s): Buffer zones should be created around environmentally sensitive areas. In these buffer zones non-chemical control alternatives should be used to the extent possible. CPS should give high priority to encouraging traditional methods of control in these areas (see sections 5.5 and 8.3).

9.3 Survey and Crop Loss Assessment

Finding: A thorough surveillance program and preventive treatment can be less expensive and less environmentally detrimental than emergency response to major outbreaks of locusts or grasshoppers. The migratory nature of locusts and to a lesser extent the Senegalese grasshopper make regional cooperation essential in this effort.

Recommendation(s): CPS should support a vigorous surveillance program of its own and GRM should provide support to OCLALAV for regional surveillance coordination. Significant capabilities exist in the CPS to provide for

surveillance and forecasting, but personnel and equipment do not suffice to cover the entire affected region. Alternative means of obtaining the needed information, such as through trained village brigades, and enhanced use of greenness maps, ought to developed (Sect. 5.1.3, 5.1.4). A technique worth considering, as evaluated in Senegal, is to include light traps at principal field bases, operated through the night and permanently manned during the grasshopper season (see sections 4.4, 5.5).

Finding: The data necessary for greatly improving the quality of crop loss assessment can be compiled over a number of years.

Recommendation(s): The effort necessary for greatly improved crop loss assessment must be undertaken as a priority (see section 4.3). This will need to be coordinated with food security assessments and carefully developed in light of socio-economic considerations. Conduct cost/benefit studies on treatments done to control grasshoppers and locusts. There are no good statistics or studies with a true evaluation of crop loss caused by the acridid pests.

Finding: Donors are sometimes too quick to respond to requests for assistance. For example, large numbers of early instar nymphs do not necessarily constitute a problem, because mortality of nymphs may be high or timing of crop harvest may avoid unacceptable losses. In addition, many grasshopper species spend their entire lives in close proximity to where they hatched.

Recommendation(s): A.I.D should not respond to requests for assistance unless a reasonable probability exists that significant crop losses will occur without intervention. Under certain circumstances, it may be appropriate to send an outside expert to verify the need for intervention (see sections 4.3, 5.3 and 5.4). Furthermore, "local" species should be considered a crop protection problem to be handled as a normal part of CPS operations (see section 5.1).

9.4 Education, Training and Technical Support

Finding: Education and training is given appropriate priority by the CPS, particularly as related to the needs of the crop protection and rural developments agents, but limited resources compromise the quality and frequency of training, which should occur every year. The village brigade training thrust is very promising, but needs considerable strengthening. Peasants can play the main role in control efforts through surveillance, communicating observation, destroying egg-pods, controlling larval concentrations, and the like. A present emphasis is being put upon pesticide application skills, which has distinct attendant dangers. Over 600 brigades were trained in 1989 and 1990 alone.

Recommendations: Expand training for: Crop Protection agents responsible for acridid control activities in the field. Emphasis should be on reinforcement of knowledge about acridids, especially immature stages and ecology; mastery of control techniques and of general health and safety procedures to follow; and Rural Development agents who are extension agents and motivators for the farmers and their families; Farmers should be able to identify the acridid species which are economically important in their zone, to know the appropriate treatment techniques as well as the precautions to take during pesticide use. Regarding the village brigades trained for

pesticide interventions, the recommendations given in Section 5.2.2 should be followed. Collaboration should be sought between the CPS pesticide safety trainers and the public health service training cadre. Applying safety measures requires use of pedagogical tools: rural press; pictograms (INPS); the training and motivating of hygiene committees wherever toxic products are handled; participation of villages already involved in education and public awareness, such as health agents (hygienist, first aid technician and extension agents.

Finding: The level of expertise needed in a number of areas related to grasshopper and locust control for the near future is not sufficient in either USAID/Bamako or CPS. These areas include environmental topics, such as drum recycling and obsolete pesticide disposal, and entomology topics, such as isolation of natural pathogens of grasshoppers or locusts. Senior and specialist-level staff are not available at the CPS in several key areas, such as plant quarantine, vertebrate pest management, biological control, and operations management.

Recommendation(s): USAID/Bamako should continue to provide technical assistance from AID/W, USDA and EPA, or elsewhere as needed. In all cases, this technical assistance should be provided in ways that enhance the expertise of the host government, for example having experts work closely with counterparts in CPS or elsewhere in GRM (see, e.g., section 5.2)

Medium- and longer-term training opportunities should be found to train selected staff as specialists in priority areas, such those mentioned above.

Finding: The 1989 USAID-sponsored seminar in Bamako on "Health Aspects of Pesticide Application" was beneficial for both crop protection and public health agents.

Recommendation: Such training ought to be repeated in regions where pesticide use is significant, and the productive association with the public health service encouraged.

9.5 Control Operations and IPM Alternatives

Finding: A detailed work plan for control operations can contribute greatly to rational planning and to health and environmental safety.

Recommendation(s): CPS should prepare a current work plan describing the details of intended operations. Ideally, the work plan should indicate how the recommendations in this SEA will be implemented (see Sect. 5.1, 5.3).

Findings: Greater farmer involvement, especially early in the development of grasshoppers, can prevent the need for greater pesticide intervention later. This can be especially true for cultural controls, alternate crops and inter-cropping. For example, weeding of crops and margins of fields appears to be effective in reducing numbers and damage of grasshoppers (Sect. 5.5). An extension of this insight might be that road maintenance crews could be instructed to keep roadsides near fields cut, thus a local source of grasshopper infestation would be reduced.

Recommendations: CPS should greatly increase its training of farmers and others in techniques to minimize infestations, working with others in identifying, and elaborating through applied research, appropriate alternative

techniques (see sections 5.1, 5.2, and 5.5).

Finding: Timing of control operations can greatly influence the extent of intervention needed. For example, first generation L1 to L3 young nymphs of Senegalese grasshoppers are generally concentrated and can be attacked in relatively small areas, thus they are a good target. Nymphs of L3 to fledgling adults tend to become more dispersed.

Recommendation: Control operations should be conducted at a time of maximum effectiveness of the control agent, before populations disperse over a wide area and before generations begin overlapping (see section 5.3).

Finding: Excellent potential exists for progress in developing programs of research and development on alternative approaches to managing grasshoppers and other pests, based on progress achieved in recent years by the GRM in cooperation with NRI, FAO-UNDP, USAID, and others.

Recommendation: Through the Institute d'Economie Rurale (IER) and CPS, and in collaboration as appropriate with other agencies, donors, ICRISAT, etc., USAID could support an applied research program on methods of biological control, traditional control and integrated pest management. This research should include, for example (Sect. 5.5): the use of neem, Azadirachta indica, for the protection of subsistence crops in the Sahel; the pursuit of trials with biological control agents of acridid species; evaluation of agronomic and cultural techniques as elements of an IPM approach.

9.6 Pesticide Management and Disposal

Finding: The major stocks of obsolete pesticides in Mali consist of at least 80,000 liters of dieldrin, 25,000 liters of lindane 16% ULV, 12,000 liters of fenitrothion ULV, 400 liters and 575 kg of BHC, 630 liters of parathion ULV, and various amounts of miscellaneous pesticides. Nearly all of the above are at least 15 years old.

Recommendation(s): Proper disposal of these chemicals is essential but should not be undertaken until a best technology for the local situation is determined. Overpacking and consolidation of the obsolete stocks should be high priority for the near-term future. A Plan of Action for Mali has been outlined (Appendix E) by the CPS. USAID/Bamako may want to consider supporting a feasibility study. A plan being developed in Niger for removal and disposal of 73,000 l of dieldrin, should be carefully followed by Mali because the situation in Mali is analogous to that in Niger (Sect. 6.4). Attempts should be made to put this issue onto the agenda of the inter-ministerial committee on the environment (Sect. 3.2.3).

Finding: Pesticide management systems and infrastructure in Mali are improving, but need continuing attention.

Recommendation(s): Provide support and technical assistance for training in logistics and operations management. Construct and improve structures for pesticide storage. This will allow stock maintenance with optimal product life and safety to the handlers and users, and would enhance advance planning by allowing for strategic stocks to be in place well in advance in the event of an outbreak. For major interventions involving potentially large donor inputs, a pesticide bank concept should be introduced by the donor, providing a ready reserve, quickly mobilizable (10-21 days) if the need is verified. In this way, the risk of accumulating excess stocks is

greatly reduced.

Finding: Accumulation and misuse of empty pesticide containers continues in at least some parts of Africa and constitutes a serious risk to health. Over 1600 empty or partially empty old barrels have been identified in Mali.

Recommendation(s): Disposal and/or recycling of empty pesticide containers in Mali should be under the jurisdiction of the GRM; since Mali has a local pesticide formulation manufacturer, reformulation, recycling, or reconditioning is highly recommended. USAID support will include follow-up on disposal of all drums originally provided by the USG. In addition, USAID will assist CPS in disposal of all used drums. See Section 6.3 and the Action Plan (Appendix E).

9.7 Options for USAID in Implementation

No control operations

This involved withdrawal of USAID assistance so that other national and international organizations would implement control operations as required, if above GRM capacity to handle. This action would permit USAID to divert funds now allocated to control to other activities perceived to bring better returns. This would also avoid USAID's involvement in the management of pesticides, which would at the same time remove the USG from a position of exercising leverage in promoting environmentally sound control programs. This option also has the disadvantage that during important outbreaks, when the acridids put crops at risk, USAID would be deviating from a priority of the Malian government.

Assistance with "Food Aid"

This alternative could appear more economical for USAID. But for Mali, such a policy would create a dependence which does not conform to the policy of food self-reliance advocated by the government.

Continued participation by USAID

USAID has been very active in supporting locust and grasshopper control in Mali, including the purchase of pesticides, if necessary. Strong emphasis is placed upon minimizing pesticide use, however, and upon mitigating potential impacts to the extent possible. Wherever the U.S. renders development assistance involving pesticide use against l/g, this SEA provides the legal context for such use, which strives to conform with U.S. environmental protection legislation.

A three-year program of USAID assistance to the GRM, focusing on training, biological control, and institutional support for monitoring and execution of ground control campaigns, has been implemented with the Crop Protection Service. Items for consideration for U.S. AID financing, depending on availability of funds and further elaboration of the three-year program, include:

a. Training. (i) acridid specialists, field technicians specialized in locust control, and ecologists familiar with immature stages and a broader

range of crop pests, (ii) operations management at the CPS, and (iii) village brigades, among others.

b. Preventive Desert Locust Control. Promoting and strengthening the capability of the CPS to mount effective and continuous surveillance and preventive control activities in the Desert Locust recession breeding areas -- the areas of known or predicted reproduction -- of Mali.

c. Improvement and reinforcement of the Crop Protection Service for the implementation of locust and grasshopper control activities.

d. Improvement of crop loss assessment, efficacy evaluations and environmental monitoring.

e. Promotion of biological control and IPM of grasshoppers through applied research and on-farm trials, in collaboration with IER and donors;

f. Close coordination between the Crop Protection Service and the Meteorological Service at both a national and regional level so as to take advantage of climatological and ecological data to produce a better understanding of the principal acridid species.

g. Providing for vegetation index (greenness) maps, with improved delivery time and interpretation, to aid in survey for desert locusts.

h. Establishment of a system for collecting and distributing information and coordinating information exchange between Sahelian countries.

i. Improved pesticide management practices, to include storage, labelling, containment and disposal of obsolete and surplus stocks.

This project is expected to significantly assist the Crop Protection Service in increasing its effectiveness, in becoming less dependent on emergency aid, which tends to be inadequately planned.

The activities of this project would have to be closely coordinated with those of the UNDP Project PNUD/FAO/MLI/86/009, reinforcing the Crop Protection Service of Mali, and with those of other major contributors, such as GTZ, NRI and Ciba-Geigy.

10.0 BIBLIOGRAPHY

Alomenu, H.S. 1989. Provisional Report on Pesticide Management in Francophone West Africa. Food & Agriculture Organization, Accra, Ghana, 58 pp.

Appleby, G., W. Settle and A. Showler. 1989. The Africa Emergency Locust/Grasshopper Assistance Mid-term Evaluation, Tropical Research & Development, Inc., Gainesville, Florida, 146 pp.

Boberschmidt, L., S. Saari, J. Sassaman and L. Skinner. 1989. Pesticide Background Statements, Volume IV, Insecticides. Agriculture Handbook No. 685, U.S. Forest Service, Washington, DC, USA, 578pp.

Bouaichi, A. 1990. Assistance Technique à la Protection des Végétaux, Mali. Rapport de Mision (12.V.au 30.XI.1990). FAO [ECLO/RAF/019/USA] Rome and Bamako. 46 pp. + annexes.

Castleton, C. et al. 1991 (in prep.). Evaluation of the Village Brigades for Crop Protection in the Sahel. Report on a FAO/OCLALAV Mission to Chad, Mali and Senegal, August - September 1990.

Cavin, G. 1989. Trip Report-Grasshoppers in Sénégal, USAID, Bamako. 10 pp.

Coop, L.B. et al. 1989 a-c. Economic Analysis of African Locust/Grasshopper Control: GHLSIM model. [Part I: Technical Reference, 35 pp.; Part II: User's Manual, 44 pp.; Part III: Analysis of the 1987 Campaign in Chad, 56 pp.] International Plant Protection Center, Oregon State Univ., Corvallis, Oregon.

Coop, L.B. and B.A. Croft. 1991 (in press). A decision-support system for Economic Analysis of Grasshopper Treatment Operations in the Sahel. Crop Protection.

Diallo, T. and O.S. Yonli. 1991. Rapport d'execution de l'action pilote de lutte preventive contre les sauteriaux du complexe des savannes dans le Secteur O.H.V. de Banamba. Min. du Dev. Rural et de l'Envir., Serv. Prot. Veg. 6 pp. + Rapport du Mission d'Evaluation.

Dieme, S. 1981. Some insect pests on the main crops in Senegal, West Africa. MS Thesis, Oklahoma State University, Stillwater, Oklahoma, USA, 60 pp.

DNSP. 1989. Plan de dévolution du Plan du Programme de Surveillance et de Lutte contre l'Onchocercose, la Trypanosomiase et les Maladies cécitantes. Direction Nationale de la Santé Publique, Bamako.

Dominique, G. 1989. Agricultural Development in Drought Zones. PIE Report for July to October 1989. CARE, Macina. 24 pp.

Doumbia, Y.O., Bonzi S.M. 1989. Les insectes du mil et du sorgho au Mali, distribution et dégâts. Agronomie Tropicale (in press)

DYNAMAC. 1988a. Results of the Mali Pesticide Testing Trial Against the Senegalese Grasshopper. Dynamac Corporation, Rockville, Maryland, USA, 111 pp + Appendices.

DYNAMAC. 1988b. Results of the Locust Pesticide Testing Trials in Sudan. Dynamac Corporation, Rockville, Maryland, USA, 84 pp + Appendices.

DYNAMAC. 1988c. Progress Report on the Results of Mali-Sudan Pesticides Testing Project, AELGA. USAID Contract # AFR-0517-C-00-7035-00. Arlington, Virginia.

Everts, J.W., Elsen A.C., Doumbia Y.O., Koeman J.H. 1981. L'impact sur l'environnement de la région du Sahel de la lutte intégrée contre les ennemis des principales Cultures Vivrières. Rapport de mission et Plan de Recherche. Edité par la Section de Toxicologie, Université Agronomique de Wageningen Pays Bas. pp?

Everts, J.W. 1990a. Methods for monitoring the impact of chemical control of locust and grasshoppers in Africa, pp.45-54. In: Proceedings of the Workshop on Health and Environmental Impact of Alternative Control Agents for Desert Locust Control. Oslo, Norway. Jan. 14-17, 1990. Development and Environment No. 5, NORAGRIC Occassional Papers Series C.

Everts, J. W., ed. 1990b. Environmental effects of chemical locust and grasshopper control in Senegal. A pilot study. ECLO/SEN/003/NET Project Report. FAO, Rome.

FAO. 1971. Manuel sur l'Utilisation des Normes FAO pour les Produits Phytopharmaceutiques. Rome.

FAO, 1986. Code International de conduite pour la distribution et l'utilisation des pesticides. FAO, Rome. 28 pp.

FAO. 1989. Report on the Obsolete Pesticide Stocks of Chad and Mali (Oct. 1989) (P. Ruelle and M. Butros).

FAO. 1990. Report on the West African Pesticide Management Workshop. Accra, Ghana (Sept. 1989).

FAO. 1991 (in prep.) Inter-regional Program of Preventive Desert Locust Control in West and North-west Africa. A Five-Year Plan.

GIFAP. 1983. Guidelines for Safe Use of Pesticides. Brussels. 54 pp.

GIFAP. 1988. Directives sur l'Utilisation, et le Stockage des Pesticides. Bruxelles. 62 pp.

Halter, Faith. 1989a. General Suggestions for Project of the Government of the Republic of Mali to Review All Laws Pertaining to the Environment. Report to USAID/Bamako. 11 pp.

Halter, Faith. 1989b. Implementing the Law Banning Toxic Waste Imports. Comments prepared for USAID/Bamako, Mali. 6 pp.

Halter, Faith. 1990. Improving Governemnt Programs for Environmental Health in Mali. Report for USAID/Mali (Sept. 1990). 24 pp.

Huden, G.H. 1990. Pesticide Disposal in a Cement Kiln in Pakistan: A Pilot Study. U.S.A.I.D. Office of Foreign Disaster Assistance.

IAPSC/CCTA. 1964. Mémorandum sur les Méthodes de Protection Phytosanitaire

Applicables en Afrique. Interafrican Phytosanitary Council. Publ. # 82.

INSAH-UCTR-PV. 1991a. Journées d'Etudes sur la Protection des Végétaux dans le Sahel: Comptes Rendu. Jan 7-12, 1991. Bamako, Mali 26+5 pp.

INSAH-UCTR-PV. 1991b. Colloque sur le Profil des Pertes sur le Mil au Sahel. Sahel PV Info, No. 31 (April 1991), p. 7-23.

I.U.C.N. 1989. Projet de Conservation de l'Environnement dans le Cercle de Youvarou, Mali. Union Internationale pour la Conservation de la Nature et de ses Ressources. Geneva, Switzerland. 53 pp.

Keith, J.O. 1990 and W.C. Mullié. The Effects of Fenitrothion and Chlorpyriphos on Birds in the Savannah of Northern Senegal. Denver Wildlife Research Center, Denver. Colorado. 37 pp.

Kremer, A. 1991. Economic Methods in Plant Protection. NRI-ODA. Unpublished paper [17 pp.] presented at Crop Loss Assessment Colloquy, Ouagadougou, Burkina Faso, March 19-22, 1991. INSAH-UCTR-PV and A.I.D. Africa Bureau [summary appears in colloquy report, INSAH-UCTR-PV 1991 b].

Jensen, J.A. 1987. Trip Report and Observations Made on Pesticide Disposal Survey Team, Sudan, Ethiopia, Kenya and Somalia. CICP, College Park, Maryland.

LeCoq, M. and J. Mestre. 1988. La Surveillance des Sauteriaux du Sahel. Coll. Acridol. Operationelle No.2. CILSS/DFPV/PRIFAS. 62 pp.

Loken, E.R. 1988. Environmental Assessment Update - Morocco Locust Control Project Paper Supplement (Annex B), Agency for International Development, Rabat, Morocco.

MASI. 1986. La lutte contre les acridiens et les oiseaux granivores au Mali. Rapport présenté à l'OFDA. 119 pp.

MASI, Development Services Division. 1986. Locust, Grasshopper and Grain Eating Bird Control In Mali. Report presented to OFDA. 111 pages.

Ministère de la Santé Publique et des Affaires Sociales. Direction Nationale de la Planification et de la Formation Socio-Sanitaire, Annuaire Satistique 1988.

Morgan, D. P. 1989. Recognition and Management of Pesticide Poisonings. 4th Edition. EPA-450/9-88-001. Environmental Protection Agency, Washington, DC, USA, 207 pp.

OCLALAV. 1991. [Report on Annaul Meeting], Niamey,Niger. 28-29 Jan. 1991.

O.P.S.R. 1985. Rapports Annuels. Operation Protection des Semances et Recoltes, Bamako.

O.P.S.R. 1986. Rapports Annuels. Operation Protection des Semances et Recoltes, Bamako.

O.P.S.R. 1987. Rapports Annuels. Operation Protection des Semances et Recoltes, Bamako.

Popov, G.B., 1978. Les sautériaux au Sahel. Résumé des travaux du Projet de recherche et de vulgarisation COPR/OCLALAV sur les sautériaux du Sahel dans la moyenne vallée du Niger, Août 1976 à Décembre 1978. FAO No.AGP/DL/TS/25. 123 pp. [NB: appeared in a condensed English version in 1983, published by ODNRI]

Popov, G.B. 1989. Joint Nosema, Insect Growth Regulator and Insecticide Trials Project in Mali. Report of Consultant to Ciba-Geigy, FAO, and SPV. 25 pp.

Popov, G.B. 1990. Field Training Course in Recognition of Nymphal Stages of the Common Sahelian Grasshoppers and Assessment of their Numbers and Potential Economic Importance. Report of Contractor to USAID/Mali, Bamako. (September 1, 1990) 28 pp.

Popov, G.B. 1991. A Training Course on Egg-pod Survey: Strategy, Methodology, Evaluation of Results, and Control of Egg-pods as part of Grasshopper IPM at the Farmer Level. Report of Contractor to USAID/Mali, Bamako. January 17 - February 17, 1991. 34 pp.

Popov, G.B., M. H. Launois-Luong and J.J. van der Weel. 1990. Les Oothèques des Criquets du Sahel. Acridol. Operationelle Ser. No. 7. DFPV/CILSS/PRIFAS. 140 pp.

Potter, C.S., M.G. Rutanen-Whaley, H. Khoury and A. Messer. 1988. Draft Environmental Assessment of the Tunisia Locust Control Campaign. Agency for International Development, Tunis, Tunisia, 48 pp.

Rutanen-Whaley, M. G., G. E. Cavin, R. W. Dyer, J. J. Drea, R. G. Hellyer and R. S. Stryker. 1988. Environmental Assessment of the Morocco Locust Control Project. Agency for International Development, Rabat, Morocco, 30 pp + Appendices.

Schwartz, T. K., M. F. Speers, G. P. Owens, J. B. Hannum, O. M. Ali, A. Gamal and S. El Bashir. 1988. Environmental Assessment of the Sudan Locust Control Project. Agency for International Development, Khartoum, Sudan, 62 pp.

Shaikh, A., E. Arnould, K. Christophersen, R. Hagen, J. Tabor, and P. Warshall. 1988. Opportunities for Sustained Development, Successful Natural Resources Management in the Sahel. Agency for International Development, Bureau for Africa, Sahel Office, Four Volumes.

Shannon, M. et al. 1987. Rangeland Grasshopper Cooperative Management Program, Final Environmental Impact Statement. Animal and Plant Health Inspection Service, U.S. Department of Agriculture, Washington, DC, USA, 251 pp + Appendices.

Sivakumar, M.V.K., M. Konaté, and S.M. Virmani. 1984. Agroclimatologie de l'Afrique de l'Ouest: Le Mali. ICRISAT? Bull. d'information No.19.

S.P.V. 1988a. Doses d'utilisation des Pesticides en Lutte Acridienne: dose en Grammes Matière Active à l'Hectare (GMA/Ha). Service National en Protection des Végétaux, Bamako, Mali. 1 p

S.P.V. 1988b. Insecticides utilisés par la Protection des Végétaux au Mali. Campagne agricole 1985-1986 à 1988-1989. Service National en

Protection des Végétaux, Bamako, 3 pp

S.P.V. 1988c. Liste des Pesticides ayant été utilisés, en utilisation, formulés ou commercialisés au Mali. Service National en Protection des Végétaux, Bamako,

S.P.V. 1988d. Rapport Annuel d'Activité, Campagne 1988-89. Service National en Protection des Végétaux, Bamako, Mali.

S.P.V. 1989a. Rapport Annuel. Service National en Protection des Végétaux, Bamako, Mali.

S.P.V. 1989b. Rapport National de Mali. Communication présenté à l'Atelier régional sur la gestion des pesticides, Accra, 4-8 Septembre 1989. Service National en Protection des Végétaux, Bamako, Mali. 39 pp.

S.P.V. 1990. Rapport Annuel. Service National en Protection des Végétaux, Bamako, Mali. 40 pp.

S.P.V. 1991a. Bilan de la Campagne de Lutte Antiacridienne du Mali. Sahel PV Info No. 29, Dec. pp. 2-6.

S.P.V. 1991b. Protection des Végétaux au Mali. Journées d'Etudes sur la Protection des Végétaux dans le Sahel. INSAH-UCTR/PV. Bamako, 7-12 Jan. 1991.

Stanley, R., G. Cavin, M. Engler, and S. Powers 1990. Supplemental Environmental Assessment of the Senegal Locust/Grasshopper Control Program. USAID/Senegal. Dakar, Senegal.

Steedman, A. (ed.) 1988. Locust Handbook. 2nd edition. Overseas Development Natural Resources Institute, London, England, 180 pp.

Strzok, P.P., E.B. Radcliff, H. Larew, R. Swanson and G. Ouedragou. 1989. Design of a Neem Kernel Extract Project for Crop Protection in Mali. Agency to Facilitate the Growth of Rural Organizations, Minneapolis. 39 pp.

TAMS. 1983. Les Ressources Terrestres au Mali. Vol. II. Rapport Technique. Tippetts-Abbett-McCarthy-Stratton Consultants, Inc., NY.

TAMS. 1989. Locust and Grasshopper Control in Africa/Asia, A Programmatic Environmental Assessment. TAMS Consultants, Inc., Arlington, Virginia, USA, 305 pp + Appendices.

Traoré, M. et al. 1980. Atlas du Mali. Editions Jeune Afrique. Les Editions J.A., Paris 64 pp.

United Nations. 1983. Formulation of Pesticides in Developing Countries. United Nations, New York. pp?

US A.I.D. 1988. Grasshopper/Locust Workshop Report and References. Harper's Ferry, West Virginia. 309 pp.

US A.I.D. 1989a. Locust/Grasshopper Management Guidebook. Office of Foreign Disaster Assistance, Agency for International Development,

Washington, DC, USA.

USAID. 1991. Report on West African Regional Workshop on Pesticide Disposal, January 20-26, 1990. Niamey, Niger. AID/AFR/TR/ANR. Washington, D.C.

USAID/Niger. 1989b. Implementation Plan for Government of Niger to Reduce Hazard of Surplus and Unusable Insecticides Acquired for Use in the Locust/Grasshopper Program. Agency for International Development, Washington, DC.

USAID/Niger. 1991. Operations Plan for the Removal and Disposal of Dieldrin Stocks from Niger. Niamey. 75 pp.

U.S. Congress, Office of Technology Assessment. 1990. A Plague of Locusts -- Special Report. OTAOF-450. U.S. Government Prinitng Office, Washington, D.C. 129 pp.

Warshall, P. 1989. Mali Biological Diversity Assessment. EDI, Washington, DC. 95 pp.

World Health Organization (WHO). 1989. Aldrin and Dieldrin. Environmental Health Criteria No. 91. Geneva.

W.H.O., O.C.P./G.V.A/85.1A. 1988. Dix années de Lutte contre l'Onchocercose en Afrique de l'Ouest, 1986-87.

World Environment Center, 1987. Pesticide Disposal in East Africa. New York.

150