SUPPLEMENTARY ENVIRONMENTAL ASSESSMENT
OF THE SENEGAL LOCUST/GRASSHOPPER CONTROL PROGRAM

United States Agency for International Development

Mission to Senegal

In cooperation with the Government of Senegal

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PREFACE

This document is a supplement to the Programmatic Environmental Assessment (PEA) concerning USAID assistance in Grasshopper/Locust control programs. This Supplementary Environmental Assessment (SEA) was prepared by an AID/W (AFR/TR/ANR/NR) assistance team, the A.I.D. Mission to Senegal, with support from the Government of Senegal (GOS). Document preparers and contact persons are listed in Appendix A.

This document has been reviewed by A.I.D./Senegal, the Government of Senegal and AID/W. It reflects the best current description of the future directions of the USAID assistance program to the Senegal Crop Protection Service for locust and grasshopper management. It contains the best estimates of environmental impact amd possible mitigating strategies. This may include training programs covering improved health and environmental protection, support for early survey and spot treatment programs, and encouragement for environmentally sound pesticide management. The commitments for any possible future program are contingent on the future needs for grasshopper or locust control, the capabilities of the Senegalese CPS, and on a decision by A.I.D. to provide assistance.

LIST OF ACRONYMS AND ABBREVIATIONS

AChE	AcetylCholinesterase
AELGA	African Emergency Locust/Grasshopper Assistance Project - USAID/Washington
APHIS	Animal and Plant Health Inspection Service of USDA
CFA	West African currency
CFR	US Code of Federal Regulations
CPS	Crop Protection Service
EA	Environmental Assessment
EPA	US Environmental Protection Agency
FAO	Food and Agriculture Organization of the United Nations
GOS	Government of Senegal
ha	hectare
IPM	Integrated Pest Management
ITCZ	InterTropical Convergence Zone
IITA	International Institute for Tropical Agriculture, Ibadan, Nigeria
km	kilometer
mg/kg	milligram per kilogram (body weight)
OCLALAV	Organisation Commune de Lutte Antiacridienne et de Lutte Antiaviaire
PEA	Programmatic Environmental Assessment
ppm	parts per million (ambient concentration)
PRCA	The Pesticides Registration and Control Act (of Senegal), 1984
REDSO	Regional Economic Development Support Office

SEA	Supplementary Environmental Assessment
USAID/W	U.S. Agency for International Development, Washington, DC
USAID/Senegal	USAID Mission to Senegal, located in Dakar
USDA	U.S. Department of Agriculture

1.0 EXECUTIVE SUMMARY

This assessment is a supplement to the Programmatic Environmental Assessment (PEA) for Locust and Grasshopper Control in Africa and Asia. It was developed to provide explicit, country-specific environmental details and guidance in Senegal in order to allow AID assistance in regard to Locust and Grasshopper Management. It is therefore a extension of the PEA and is, as such, an integral part of it.

The information contained in this document is intended for use by USAID/Senegal and the Senegal CPS to guide environmentally sound locust and grasshopper management. However, the discussions herein need not be limited to these specific pests, provided that consideration is given to the climatic, biological, and environmental diversity of Senegal. Additional relevant information should be added to this SEA as needed, as this is a dynamic, rather than static document. As part of the PEA, both documents should be consulted during both planning and operational stages of implementation.

Survey and immediate treatment operations are considered foremost in preventing locust or grasshopper outbreaks. Prevention is the key to reduce crop loss and pest control operation costs. Early season intervention requires considerable less pesticide than late season emergency operations, and therefore has less impact on the environment.

Environmental awareness is emphasized. Fragile ecological areas need to be protected from pesticides, as the impact can be both dramatic and long lasting. Buffer zones of at least 2.5 kilometers surrounding fragile areas should be supported in any U.S.-funded control operation.

Pesticide management must be a priority in control operation programs. Because misused pesticides effect both the environment and crop production in terms of increased costs, any control program must consider possible consequences carefully. Pesticide container disposal must be conducted so as to eliminate food or water storage in used containers. In this regard, supportive legislation and regulations must be enforced to promote sound pesticide management practices.

Training should be part of any USAID assistance program. Pesticide safety and the environmental effects of pesticide use and misuse should be conveyed to both CPS personnel, and the general public through education and public awareness campaigns. Farmer training and Village Brigades can be an important part of management operations, and should be stressed.

If possible, the Senegal CPS should work towards a laboratory analysis program to monitor pesticide formulation quality and

environmental residues. Analysis of blood AcetylCholinesterase testing in pesticide handlers and applicators is supported.

Monitoring of pesticide effects on non-target species and the environment should be included as an integral part of any pesticide use program. Monitoring results should be used in the planning and operational phases of future locust and grasshopper control programs to adjust or curtail environmentally damaging operations.

The stock of obsolete pesticides in Senegal includes 30,000 liters of dieldrin. Proper disposal of this and other unwanted pesticides is essential. Disposal and/or recycling of empty pesticide containers in Senegal should be under the jurisdiction of the GOS; since Senegal has a local pesticide formulation plant, container recycling is highly recommended.

2.0 PURPOSE AND PROCEDURES

2.1 Background

With the latest major upsurge of the Desert Locust (Schistocerca gregaria) in Africa beginning in late 1986 and lasting into 1989, and extensive grasshopper (numerous species) outbreaks throughout the Sahel from 1986 through 1989, the U.S. government was called upon by concerned African nations to assist with technical expertise and needed materials in the management of these insects. 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. The waiver permitted A.I.D. to provide assistance for procurement and use of pesticides for locust/grasshopper control without full compliance with the Agency's environmental procedures. The Administrators waiver expired on August 15, 1989.

Any future A.I.D. assistance for procurement and use of pesticides must fully comply with the Agency's environmental procedures. In 1989, a Programmatic Environmental Assessment (PEA) was completed. The PEA, and the country-specific Supplemental Environmental Assessments (SEAs) will serve as the basis for these regulatory procedures. The SEAs contain specific environmental information for each of the Sahelian countries, and provide guidance on environmentally sound management procedures.

Given the periodic nature of locust outbreaks, and the cyclic population fluctuations of grasshoppers, control campaigns for these insects are likely to continue indefinitely in Senegal and elsewhere in the Sahel. Both locusts and grasshoppers are part of the ecology of the Sahel and Sahara, and will readily take advantage of agricultural crops. Control measures must manage problematic insects at economically reasonable levels in regard to crop loss, rather than try to achieve extermination.

Because of the both periodic and cyclic fluctuations of locusts and grasshoppers, and their potential impact upon food supplies, it is likely that requests for A.I.D. technical assistance, aerial application services, commodities, equipment and/or insecticides will continue. It is likely that most of these requests will be related to the use of chemicals for control operations, either directly or indirectly. For A.I.D. to positively respond to such requests, the Environmental Procedures in Regulation 16 (22 CFR 216) must be followed. Along with the PEA, this document fulfills the requirements necessary to allow A.I.D. to provide assistance to Senegal.

2.2 Scoping Procedure

A.I.D. Environmental Procedures (22 CFR 216.3(a)(4), describes the scoping process to be used in identifying 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 were described by cable Dakar 11068, approved by A.I.D./W in State 316101.

A draft outline for the Supplemental Environmental Assessment (SEA) and a list of sources of information were developed by USAID/Senegal and AID/W TA. The USAID/Senegal Agricultural Development Office (ADO) oversaw the scoping process, wrote parts of the SEA, and organized all needed reference documentation.

USAID/Senegal, with the assistance and participation of the Director of the Crop Protection Service within the Ministry of Agriculture, worked cooperatively to facilitate the drafting of the SEA, and to ensure smooth implementation of the this guidance document. The individuals members of the SEA committee, as well as those who contributed to the writing of the SEA are listed in Appendix A.

2.3. Previous Assessments

The previous assessment concerning this subject, and the primary supportive document is the *Programmatic Environmental Assessment for Locust and Grasshopper Control in Africa/Asia* (TAMS/CICP, 1989) (PEA). The PEA covers grasshopper and locust control operations in Africa and the Near East. This SEA is a supplement to the PEA, and should be considered an integral part of the PEA. This document concerns the country-specific environmental issues not addressed in the PEA.

Other assessments in regard to l/g include:

(1) *The Africa Emergency Locust/Grasshopper Assistance Mid-term Evaluation*. (with specific-country case studies for Chad, Mali, Niger, Mauritania, and Cape Verde) (Appleby, Settle & Showler, 1989);

(2) *Provisional Report on the Handling of Pesticide in Anglophone West Africa*. (Youdeowei, 1989, FAO Conference report, Accra , Ghana);

(3) *Provisional Report on Pesticide Management in Francophone West Africa*. (Alomenu, 1989, Report to the FAO Conference at Accra, Ghana);

These documents have been used freely in the preparation of this assessment and are often relied on without citation. Internal USAID/Senegal data are used without citation. Other relevant documents are cited in the text when supportive data is used.

2.4. Environmental Procedures.

It is A.I.D. policy to ensure that any negative environmental consequences of an A.I.D.-financed activity are identified prior to a final implementation decision. This document covers specific environmental consequences involved with pesticide use, and necessary safeguards and mitigation for any future control programs.

Although Senegal does not have procedures equivalent to the National Environmental Policy Act (NEPA) or A.I.D. Environmental Procedures. Senegal does have regulations governing the substance of such programs. These are covered in the following section. Procedurally, A.I.D. Environmental Regulations and Procedures will be controlling for the present because they are more comprehensive and more applicable to A.I.D. programs and projects.

2.5 Senegal Environmental Procedures

2.5.1. Pesticides in Senegal Regulations.

To facilitate the proper and safe use of pesticides, regulatory laws are necessary. These regulations cover the importation of pesticides, the distribution to agricultural areas, the actual use of the pesticide, and the disposal of unwanted pesticide and used containers. These laws mandate governmental authorization prior to the importation of pesticides.

Senegal has a Pesticides Registration and Control Act (No. 84-14) (PRCA) signed into law in February, 1984; a Decree on the Application of PRCA, signed in May, 1984; and an Inter-Ministerial Administrative Instrument No. 0053812 signed in May, 1985 defining a National Commission on Pesticides Registration and Control. The CPS is commissioned with overseeing the application of PRCA. Senegalese law also requires the granting of pre-import clearance prior to pesticide import. The Ministry of Trade issues permits for importation.

The CPS has established a list of all pesticides accepted for use in Senegal; the list includes a number of chemicals banned or restricted elsewhere, such as DDT, dieldrin, aldrin and heptachlor. The extent to which any of these are used is unknown, although the CPS reports that dieldrin is not used. Pesticides which are recommended by this SEA to be banned in Senegal are: alachlore, chloramphenicol, chlordane, DDT, DDD, DDE, endrin, hexachlorophene, HCH, lindane, chloral hydrate, paraquat and toxaphene.

The Senegal Crop Protection Service (CPS) is currently drafting a set of regulations and procedures to more fully cover the pesticide registration process. These regulations will require a pesticide manufacturer to first submit technical data and a sample of the pesticide for testing and analysis in Senegal. Only after the CPS has thoroughly analyzed the material, and deemed it safe and effective, may the pesticide be sold and used in Senegal. While these regulations will not solve the problem of monitoring and enforcement, they will set forth a very strong base for further management actions. This SEA is encouraged by these actions, and supports the CPS in this effort.

A U.S. pesticide contribution to Senegal, or a U.S.-funded pesticide purchase in Senegal will be controlled not only by applicable Senegalese laws and regulations, but also by U.S. pesticide regulations and procedures, as described in the PEA. In this regard, only those pesticides listed in the PEA, or amendments thereof, are acceptable unless this SEA is amended to cover possible environmental impact which may result from the use of that particular pesticide. Pesticides used in a U.S. operation are to be used according to label instructions only. Used pesticide containers and any unwanted pesticide resulting from a U.S.-funded operation must be disposed of properly and safely. No U.S. funds shall be used to purchase, transport, or apply any pesticide that has been banned in the United States. This especially includes the chlorinated-hydrocarbons, such as dieldrin and lindane.

2.5.2. Other Environmental Regulations in Senegal.

Responsibility for environmental protection is divided among several different Ministries in Senegal. The Ministry of Agriculture has legislative authority for protection and management of the forests of Senegal, while the Ministry of Tourism is responsible for protection and development of the National Parks and Faunal Reserves. The Ministry of Planning and Regional Development is concerned with broad environmental issues such as pollution, climatic change, deforestation, and toxic waste. A directorate in the Ministry of Mines, Water, and Power does environmental impact studies for large projects.

In Senegal, forests, wildlife and fisheries are protected by several legislative acts. These laws define forest reserves, faunal reserves, and national parks. Forests must be allowed to regenerate (and must have management plans to ensure regeneration), and habitat in natural parks and fauna reserves must remain undisturbed, in addition buffer zones must surround national parks and protected areas. Parks are designated for fauna, flora, and soil conservation. Agricultural, grazing and forestry activities are prohibited. In addition, pesticide use in or around national parks, protected areas, and wildlife reserves, is not allowed. While these regulations exist, improvement is needed in developing adequate definitions of protected areas, enforcement of current regulations, and in increasing both environmental awareness and effectiveness of public information oriented to agriculture workers.

Any USAID/Senegal-funded programs involving pesticide use for the control of locusts or grasshoppers should follow applicable Senegalese regulations concerning the protection of designated areas. In that regard, this SEA supports the GOS commitment to protect the natural environment, and adopts any GOS mandated conditions limiting the use of pesticides, and also follows the designated zones that are protected from pesticide use.

3.0 PROJECT DESCRIPTION

Senegal has experienced intermittent desert locust infestations and chronic grasshopper problems over the past several decades. Being in an area of Africa that has widely fluctuating rainfall, Senegal can suffer from serious locust or grasshopper outbreaks. Insect infestations are compounded when productivity is lowered by other conditions such as drought, plant disease or other pest damage. Senegal will continue to experience problems from grasshoppers, and may experience future problems from locusts. While the level at which such problems may occur is difficult to predict, especially in regard to migrations from other areas, major interally originated outbreaks can be prevented by a vigorous survey and early treatment program.

Since locust and grasshopper populations fluctuate by nature, the intensity and location of future locust and grasshopper problems are uncertain. Therefore, this assessment does not focus on any specific level of intervention. Instead, it assumes a spectrum of possible interventions, from minor interventions by individual farmers to the possibility of A.I.D. assistance when the magnitude of the problem is too great for the CPS. Support for CPS programs involving training, control operations management planning, survey, and early season intervention is emphasized. Less emphasis is placed on late season emergency operations

involving aerial pesticide spraying. Because early season control operations can prevent late season emergency operations involving significant amounts of pesticides, they are less expensive in terms of environmental impact and operational costs.

3.1 Senegal - Physical Environment

Senegal, with an area of 197,000 sq. km. and a population of 7 million, is located in the Sahelian region of West Africa on the Atlantic coast (Figure 1). This region of West Africa, a zone of marginal agricultural productivity, has been put under even greater stress by increasing human and animal populations, expanding agriculture, and periodic drought. The region has yet to recover from the severe drought of 1968-73, and the low rainfall conditions observed over the last ten years.

The harsh and unpredictable climate of northern and central Senegal can put a great deal of stress on agricultural production systems. Precipitation normally occurs during the months of July to October, and is characteristically variable with respect amounts (200 mm in the north, to 1300 mm in the south) and distribution (localized and erratic). Area rainfall is a result of the interaction of southern ocean trade winds, and the hot, dry Harmattan winds from the Sahara. Yearly average temperatures range between 15 and 45 C. High temperatures, coupled with hot, dry winds can add to the stress of agricultural crops grown in Senegal.

With the exception of the soils found in river valleys and estuaries, which receive annual deposits of alluvium, the soils of Senegal are generally productivity-limiting. The red-brown soils found in the north have a good organic content, but are prone to harden with drought. In the central portion of the country, the soils are sandy, but contain very little organic matter, few micro-nutrients, and are prone to water and wind erosion. Without careful management, such as crop rotation, soils can structurally deteriorate, resulting in a loss of water and nutrient holding capacity. In the higher rainfall regions of southern Senegal, soils typical of the humid tropics are found. These soils are subject to sheet erosion caused by rain, and to rapid mineralization of the humus caused by high temperatures.

The Senegalese road system is one of the largest in Africa with over 14,000 km. of asphalt roads, and about 28,000 km of dirt roads. Both fuel, spare parts, and repair facilities are located through out Senegal. In general, there is access to all areas of the country, except after heavy rains. As these rains generally occur early in the season, they have little impact on accessibility to pest populations at optimal times. In addition to roads, Senegal also has a railway system, and numerous airports in regional capitals and towns in the interior.

3.2 Agricultural Resources

The major agronomic crops of Senegal are millet, sorghum, peanuts, rice, cotton and maize. Millet, peanuts and sorghum are grown in the central west, rice along the Senegal River in the north and the Casamance in the south, and cotton in the interior regions (Figure 2). Much of northern and eastern Senegal is pastureland. The crop most subject to locust and grasshopper damage is millet. Sorghum, and to some extent other grain crops (principally maize and rice), can also be damaged, and some losses undoubtedly occur in grasslands. Approximately three to four times as much millet is produced as rice, the second most abundant agronomic crop in 1988 and 1989.

The productivity and production of millet for 1988/89 and 1989/90 by administrative region of the country are given in Table 1. Some of the regions of greatest locust invasion in mid-October, 1988 are the same as regions of greatest cultivation of millet. For example, nearly 50% of 1988 millet production was from the Kaolack region, which was invaded that year by locusts in mid-October (see Appendix D).

Despite the harshness and unpredictability of the agricultural production in Senegal, this sector accounts for about 70% of the total labor force employment. The country is a major producer of peanuts and cereals (millet, sorghum and rice), which are produced for domestic consumption. Senegal is currently not self-sufficient in agriculture production, importing about 40% of its food needs. Therefore, any factor, such as drought or pestilence, which has an adverse effect on agricultural productivity may be considered a major economic and social threat.

Wild grazing animals were once an important source of food for the people of Senegal, but have largely disappeared due to over-hunting and the competition for forage with domestic livestock. Livestock production increased between the years of 1950-66, during a period of relatively high rainfall. However,

Table 1. Millet Production 1988 to 1990. For Various Regions of Senegal in 1988/89 and 1989/90 (from unpublished A.I.D./Senegal data).

	1988/89		1989/90	
Region	kg/ha	tones	kg/ha	tones
Dakar	454	184	650	391
Diourbel	295	37227	735	98951
Fatick	437	56062	795	119601
Kaolack	514	228322	784	247276
Kolda	548	54810	920	36200
Louga	193	26718	213	30716
Saint-Louis	477	7954	283	2329
Tambacounda	904	64599	950	36975
Thies	280	24990	486	54909
Ziguinchor	662	3772	692	5717
TOTAL	542	484638	664	633065

Table 2. Productivity (kg/ha) of Millet + Sorghum in Senegal (from US A.I.D./Senegal data).

Season	Productivity
1960/61	515
1961/62	454
1962/63	490
1963/64	499
1964/65	525
1965/66	519
1966/67	425
1967/68	567
1968/69	426
1969/70	513
1970/71	397
1971/72	601
1972/733	44
1973/74	463
1974/75	699
1975/76	639
1976/77	535
1977/78	435
1978/79	713
1979/80	538
1980/81	488
1981/82	621
1982/83	591
1983/84	425
1984/85	470
1985/86	710
1986/87	638
1987/88	746
1988/89	586
1989/90	690

the drought years that followed drastically reduced herd numbers. Today, farmers usually keep a small number of grazing animals for food use. Nomadic herders keep the larger herds in pasturelands during the cropping season, but once the crops are harvested, animals are allowed to roam freely in the remaining crop residues.

3.3 Locust and Grasshopper Characteristics

3.3.1 Grasshoppers

Grasshoppers are a perennial problem in Senegal. Economically damaging populations can be found somewhere in Senegal almost every year, but widespread outbreaks are sporadic, since this species depends on optimal rainfall and temperature conditions for rapid population build-up. Populations will build in grasslands, and will remain there as long as the grasses remain green. As the ITCZ moves south, and rainfall diminishes, the pastureland grasses will dry, inducing the grasshoppers to move in a southerly direction. If there are crop lands in the area, the grasshoppers will move into these green areas. Crop damage can be dramatic, but is usually sporadic and localized.

The Senegalese grasshopper, *Oedaleus senegalensis* (OSE), is considered the most destructive grasshopper in Senegal, with two to three generations per year. OSE eggs may remain viable for two or three years during periods of extreme drought. In contrast, eggs of most grasshoppers and locusts, without moisture, lose viability in a few months. OSE habitat is governed by rainfall (200 to 1000 mm annually, occurring almost entirely within the summer months), and the presence of light sandy soil and the availability of grasses and grains.

The Senegalese grasshopper can show some migratory-like behavior, such as the formation of loose hopper bands and migration-like movement of adults. However, unlike the desert locust, there are no morphological changes. The migration pattern follows the northern progression and southern retreat of the ITCZ weather system. Hatching of the first generation will occur 10-12 days following early summer rains of 25 mm or more. Immature grasshoppers pass through five instars and become adults within about 30 days following hatching. In Senegal, under normal conditions, about 75% of this first generation will emerge within the 75-1000 mm annual rainfall zone, or roughly the area between the northern border of the Gambia and the fifteenth parallel. A second generation occurs in mid-summer in the central portion of the peanut-growing region, and in late summer, a third generation emerges in the northern section of the peanut basin and southern Mauritania. The adult progeny of this third generation migrate south with the weather system. Eggs laid along the way enter obligatory diapause (a dormant period). Most egg laying seems to occur in the zone with 750-1000 mm of rainfall.

A somewhat similar infestation pattern occurs throughout the length of the Senegal River except that with irrigated multiple cropping regimes and flood recession agriculture, crops are threatened most of the year. Grasshopper infestations normally consist of a complex of species, with one or more dominant depending on the vegetation types and habitat. It is not possible to limit control to the Senegalese grasshopper, but intervention by A.I.D. will be limited to times and locations at which the Senegalese grasshopper is dominant.

3.3.2 Locusts

The primary migratory locust in Senegal, and through out the Sahara and Sahel, is the desert locust (*Schistocerca gregaria*). The focus of A.I.D. intervention on locusts is likely to be this species. However, Senegal lies within the invasion area of the African migratory locust (*Locusta migratoria migratorioides*). Though this species has not occurred in outbreak numbers in Senegal for several years, A.I.D. assistance may be provided for this and other species as well.

Desert locusts can breed in Senegal and solitary individuals of desert locusts are often present. However, the pattern of infestation of locust swarms in Senegal suggests that the immediate source is Mauritania and/or Mali (see Appendix D). The ultimate origins can be Niger, Chad, the Sudan, or even the Arabian peninsula and India.

Although past A.I.D. intervention has been in the emergency control of swarms, this approach is costly and often ineffective in overall impact. Further, such intervention is environmentally costly because of the huge quantities of pesticides used. A more reasonable approach, and the strategy recommended by this document, is preventative control. This relies heavily on good survey, immediate intervention, and control actions aimed at larval control, rather than swarm control.

The nature of locusts makes preventive actions in breeding areas desirable. The maintenance of populations in a recession state with minimal application of pesticides should be the strategy of choice. The historical sites of origin in Mauritania, Mali, Niger and Chad are reported to be uncultivated lands. Despite sparse human habitation, these areas might be fragile habitats that should be protected. The preference for using less volume of pesticide in a preventive program should be encouraged.

3.3.3 Other Grasshopper species

In the more tropical southern portion of Senegal (Casamance) OSE is only of minor economic importance. Nonmigratory species, such as the variegated grasshopper, *Zonocerus variegatus*, are more important. Outbreaks of this species can cause severe damage to gardens and field crops.

A number of other grasshoppers and locusts are of agricultural importance and are covered in the PEA. Other grasshopper and locust species are not expected to become a serious problem in that they would exceed the capacity of the CPS. Thus, no intervention by A.I.D./Senegal is expected for any locust or grasshopper species except the desert locust and the Senegalese grasshopper, and possibly the African migratory locust. Assistance to the CPS for operations involving these grasshoppers will primarily be in training, operations planning and preparation, survey, and early intervention.

3.4 Locust/Grasshopper Management - Overview

3.4.1 Past Locust/Grasshopper Campaigns

By virtue of its location in the Sahel, Senegal has experienced periodic invasions of locusts and grasshoppers for centuries. However, the magnitude and duration of such invasions and outbreaks were not well documented. A direct result of the drought years of the mid-60's to late 70's was significant decrease in the number of indigenous and migratory plant pests. As rainfall patterns increased in the mid-80's, a dramatic up-surge of the Senegal grasshopper was noted. USAID was requested by the GOS to assist with the control of this pest which in 1986, may have infested and impacted an estimated 1.2 million ha. of crop and range lands.

By the time the severity of the infestation was realized and understood, an aerial spray operation was deemed appropriate. A total of 1,023,423 ha. of crop land and boarding grasslands were treated: 690,323 ha. by large DC-7's funded by USAID, 305,300 ha. by small planes provided by Canada, and the remaining 27,800 ha. treated by OCLALAV with helicopters and ground spraying. The treatments were effective in minimizing crop damage, possibly reducing potential infestations the following year.

The 1988 locust infestation and subsequent control operations were similar to the grasshopper infestation in 1986 in that the extent and degree of the outbreak was unexpected. In 1988, a combination of both rainfall and wind patterns, as well as locust

breeding in other areas of the Sahel, led to a sudden and massive invasion of the desert locust. The initial US response to Senegal's request for assistance was to support a small aircraft aerial spray operation. Within two weeks however, it became obvious that the U.S. efforts, as well as those of other donors, were not sufficient to control the increasing locust infestation. USAID recommenced an aerial treatment operation utilizing large aircraft. One C-130 and two DC-7's were utilized, and treated 746,000 ha. in senegal and 41,000 ha. in the Gambia. The spray program was considered effective in protecting crops the areas treated, and may have prevented additional locust breeding in the sprayed areas.

3.4.2 Crop Loss Assessment

In considering locusts or grasshoppers, there is a basic assumption that these insect cause significant crop loss and there for must be controlled. The amount of crop yield that is lost due to an infestation of these insects is particularly important when deciding both on the level of funding needed, and the amount of pesticide to be discharged into the environment.

Crop loss information is needed to guide both the Senegal CPS and A.I.D. (as well as other donors) in the level of response which may be needed. Once the infestation levels can be related to yield loss, management operations can be more realistic in the level of effort needed. AID/W is currently supporting extensive research in Mali and Chad, as well as collaborative work with other donors and regional research organizations. Results are expected to improve l/g management considerably.

In addition to national aggregate crop losses, consideration also needs to be given to the social and economic costs of grain distribution even when losses to individual farmers or villages may be small. Even if the overall crop loss is low, some localized areas, especially in the extreme north, may experience high losses. Costs of grain transport over long distances may be more prohibitively expensive than those of a locust/grasshopper control program. Losses in grasslands are more difficult to assess than in crop lands, because the impacts are on wandering grazing animals, and thus indirect.

Crop losses will vary geographically, with extreme damage occurring near areas seeming untouched. Undoubtedly, the distribution and success of control efforts among the regions of Senegal in proportion to infestation levels are not uniform from year to year. Good crop productivity data are already available. If estimates of locust/grasshopper infestations and efficacy of control efforts were to be kept over a period of years for each region, a much better estimate of cost effectiveness could be made. This SEA strongly urges that such data be compiled and analyzed.

3.4.3 Predictability/Breadth of Operations

Neither locust nor grasshopper infestations are easy to predict in advance. Rainfall distribution is the best single predictor, but locusts and grasshoppers often occur in patterns not obviously related to any easily measured factors. Yet prediction is an essential component for taking preventive action, and preventive action is essential to maintaining locusts in recession. Therefore, surveillance is essential for tactics designed to maintain low locust and grasshopper populations. Because rainfall, and the vegetation that follows it, is important, satellite derived Greenness Maps should be used as an important guide to field surveillance.

Field survey is essential in any grasshopper management program, and must be given high priority by both the CPS and assisting donors. Included in the survey program must be a sound knowledge of pest biology, and an understanding of the impact of environmental conditions. Survey results must be relayed to the central CPS facilities in Dakar in a timely manner, so as to allow administrators time to direct logistical operations.

With sporadic pests like locusts, geographic surveillance across the Sahel is essential for preparation efforts in Senegal. Particularly because Mauritania and Mali seem to be sources for locust infestation, the preventive approach, favored in this assessment, argues for a regional approach to operational control. Despite difficulties in the past with such efforts, it is essential to continue efforts to coordinate across national boundaries.

The organizational structure responsible for control activities is the Senegalese CPS. This organization now has the expertise needed for a responsible management campaign. The CPS is responsible for planning, survey, operational control and campaign assessment. This cadre of staff, trained in pesticide use and safety precautions, should be used in operations not only against grasshoppers, but in the management of a variety of pests.

FAO is the official coordinator for locust control activities and should be supported in continuing that role. In addition, CPS and OCLALAV should be encouraged to improve their surveillance and forecasting capability. Financial support to OCLALAV by its member nations is a crucial component of a regional surveillance system and must be encouraged.

3.4.4 Level of Infestation

Grasshoppers and locusts vary over a wide range of population levels in their natural habitat, depending upon rainfall and other environmental conditions. A migrating infestation of locusts can,

depending upon wind conditions and movement patterns, have a significant impact on agriculture. For grasshoppers, crop infestation levels depend upon the numeric density and life stage of the insect. In Senegal, grasshoppers will be a problem every year to some degree. Locusts, however, are widely periodic and will fluctuate greatly over time periods of ten to twenty years.

For management planning purposes, impact on ultimate crop yield has been divided into four infestation levels. Note that these levels are quantified in relation to the intervention threshold level. The intervention threshold (also called economic threshold) is very specific to the crop, life stage of crop, insect species, and insect life stage. This concept is discussed in more detail in section 3.5.5 of this document.

Level 0 describes a low density of grasshoppers. Locusts are not considered at this level. In this regard, grasshopper density levels will below the intervention threshold level for a given species. Crop losses from this level of infestation are minor and localized. The Crop Protection Service is capable of carrying out any needed treatment programs without donor assistance.

Level I describes a situation with locust or grasshopper populations at levels which may require additional donor assistance to avoid crop loss. In this case, pest densities will be at or slightly above the intervention threshold levels. The CPS may need assistance to cover additional costs, including materials and equipment needed to reduce population levels.

Level II describes high locust or grasshopper densities with high numbers in both crops and pasture lands. Here, l/g densities will exceed the intervention threshold level. The capacity for CPS management will likely be exceeded. Significant crop loss is probable without additional donor assistance and possibly intervention.

Level III describes a situation involving very high locust or grasshopper populations extending over a large area. Again, densities exceed the intervention threshold and exceed CPS capacity. This situation will require considerable donor assistance and intervention to avoid l/g outbreaks and substantial crop loss.

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.

3.4.5 Thresholds of A.I.D. Assistance

The CPS is expected to maintain an ongoing insect management program during periods of normal pest levels. This program should include efforts to reduce human health risk, protect environmentally sensitive habitats, and minimize pesticide use through use of cultural, biological and traditional means of control. In decisions on assistance to the CPS for locust or grasshopper management activities, A.I.D. will examine both the pest situation and the capabilities of the CPS. Decisions will be made in such a way as to minimize the amount of pesticide used.

If A.I.D. does choose to participate in an assistance program, it is important that support be coordinated with other donors and the GOS to achieve a reasonable and balanced program. Assistance for such a program should emphasize the principles of IPM (as discussed in section 3.5.5), in that all available management resources should be considered. While probable crop loss will be a criterion for A.I.D. involvement in control efforts, sustainable infrastructure development and cost/benefit ratio will also be considered. Participation by A.I.D. in emergency operations will be carefully tempered with an examination of what long-term benefits will be achieved in addition to an insect population decrease. Because the use of pesticides in Africa has increased over the last few years, A.I.D. will assist primarily with a program emphasizing good survey and use of non-chemical control methods.

The level of USAID/Senegal participation in a l/g management program should not only be related to the extent and severity of the problem, but also to the extent such assistance will the CPS more sustainable. Section 3.4.4 describes different possible levels of infestation and intervention. The actual level of intervention assistance will depend upon a number of variables, including insect density, crop conditions, CPS capacity, and environmental conditions.

Prior to the implementation of U.S.-funded assistance, a through analysis of needs is necessary. In evaluating areas of assistance, USAID/Senegal should be responsive not only to the requests of the GOS, but must further ascertain what materials the CPS already has, and what other donor supported programs are planned or implemented. Supplying the CPS with an overburden of pesticides, unneeded materials, or poorly planned training will not assist in managing locusts or grasshoppers. In addition, an independent verification of pest identity, density, and potential impact should be made by a qualified technician prior to fund committal and allocation. In this regard, USAID/Senegal will likely request technical assistance from AID/Washington or REDSO/Abidjan.

3.4.6 Disaster Level of A.I.D. Participation

Should a substantial and extensive grasshopper or locust outbreak occur in Senegal, either through in-country breeding, or migration from another location, large scale operation may be needed as a last resort to protect crops, and reduce pest population levels. At such a level of intervention, risks to humans and the environment will be high, but the alternative crop loss may make intervention unavoidable.

In a situation calling for large scale intervention, all possible safeguards must be instituted, with control operational decisions built on the following hierarchy: 1) crop protection, 2) environmental protection, 3) population reduction. This places the highest priority on crop protection, and the lowest at reducing pest population numbers.

However, during a large-scale operation, the rate of accidents, overuse and use of incorrect formulations are likely to increase, because of the increased pesticide use and the pressure of panic treatments. The most important functions of the GOS has under these conditions are to institute greater local control (for example, use of Village Brigades), communicate effectively with the affected population, to describe the necessity of the emergency measures, and to ensure to the extent possible the safety of the population and the environment. Having operations at the local level, with appropriate training in safety, is greatly preferred to massive treatments by large aircraft.

During past outbreaks, the position of USAID/Senegal on pesticide application has been to support the judicious use of such chemicals for the control of food crop threatening pests. The first line of defense must be field survey work to monitor the population level of a particular pest. Proper monitoring will generally allow sufficient time to plan a strategy of control. Survey operations will also alert officials should pests be breeding at a faster rate than expected, or if a significant migration has occurred. The first line of defense isspot treatment ground applications. This involves manpower-intensive measures to directly attack the site of the infestation at early insect life stages. Aerial application is considered a last resort. This control measure is used when all others have proved ineffective or the magnitude of the threat is greater than the indigenous CPS capacity.

3.5 Locust/Grasshopper Management Operations

3.5.1 Crop Protection Service

The Senegal Crop Protection Service (CPS) is structurally in the Ministry of Rural Development and Water Resources. Included within the CPS/Dakar offices, are a Training Office, Grasshopper and Locust Office, Legislation and Quarantine Office, Entomology Laboratory, Plant Pathology Laboratory, and Pesticide Analysis Laboratory. Outside of Dakar, there are 10 Regional Inspection Stations, and 28 Departmental Offices. The CPS reports that most every village is equipped with a Village Brigade team. Included in the CPS capacity are 108 vehicles for survey and treatment operations. The 1989 annual budget of the CPS was 644,000,000 (USDOL 2,576,000). In case of a sever pest outbreak, emergency requests for additional funding will be considered by the GOS, but the past source of such funds has been donor assistance.

The survey component of the CPS is composed of six base stations (Kolda, Missirah, Nganda, Sokone, Richard Toll, and Ogo), each of which is composed of a two person team with a radio equipped vehicle. The CPS also conducts survey missions on an as needed basis within the structure of the Regional Inspection Offices, and Departmental Bureaus. Each Regional and Departmental Office have radio equipped vehicles. The CPS coordinates survey operations in part through the use of satellite Greenness Maps obtained from AGRHYMET Niamey, through the local AGRHYMET office.

Regular Donor Coordination meetings are held to discuss the current field situation, and CPS needs. This committee meets both during recessional periods for planning purposes, and during the campaign for implementation assistance.

The CPS is capable of carrying out insect management and crop protection activities when locust or grasshopper population levels are low (level 0, section 3.4.4). Through the development of a yearly action plan, the CPS can have materials and equipment prepared and ready for early season survey and control operations. Although assistance programs may be provided to the CPS at this level, particularly in the form of training, the goals of any such assistance is to increase the sustainability of the CPS infrastructure. With vigilant survey and management programs, locusts, and grasshoppers in particular, can be maintained at low population levels.

The philosophy of vigorous survey and early season management will save valuable funds and resources over the long-term, compared with costs of short-term emergency operations. Additional donor assistance may be required if high infestation l/g levels exceed the capacity of the CPS. In regard to U.S.-funded assistance

involving pesticides, the information, recommendations, and regulations discussed in this SEA and the PEA must be observed and reckoned with in project design and implementation.

By developing a strong base of trained personal and a well maintained fleet of sturdy vehicles and equipment, the CPS will be able hold impending grasshopper outbreaks, and invading locust swarms to a minimum. This will result in considerably less pesticides being used than if these pests are allowed to reach high population levels. It this regard, it is especially important to involve villagers and framers living in invasion areas in early season control endeavors. These types of efforts, combined with improved legislation and regulations will greatly lessen potential negative environmental of pesticide use. Any assistance A.I.D. can offer to build such a institution, with full participation and involvement of the Senegalese CPS, will be a far greater investment than the immense amounts which have been spent on past emergency operations (with little effect on sustainable infrastructure).

3.5.2 Survey and Control Preparations

In order to keep locust and grasshopper population numbers below levels where crop loss is imminent, and reduce the environmental impact of pesticide use, it is important to survey early in the season, and to implement control activities immediately. Trained personnel, and equipment in full working order are required to do this. The main elements to be included in locust or grasshopper survey programs are:

- Full knowledge of the physical and temporal distribution of the pest species.

- Monitoring of environmental conditions and changes which might lead to increased numbers of pest species. This will require an adequate knowledge of pest species biology, the status of environmental conditions, and how these conditions can be augmenting or limiting factors.

- A vulnerability assessment in terms of crops threatened by the pest species, including relative importance of crops, and the crop stage of development.

- The availability of pest management support resources to be mobilized for control: pesticides, application equipment, as well as logistical and technical support.

Prior to the main agricultural season, the CPS should ensure that each Field Base is equipped and prepared to face a low infestation level (level 0 in section 3.4.4) of grasshopper management. Adequate preparation would include: a working radio

teams. In addition to the basics of survey techniques, pesticide safety and application, such training must encompass a through background knowledge on pest species that require control.

While aircraft are management tools, and may be justifiably needed during locust or grasshopper outbreaks, they should be used with caution. This is because: 1) aircraft carry and spray larger quantities of pesticide than ground equipment, and therefore are more likely to have an environmental impact; 2) They are expensive to run and maintain, and are unlikely to be sustainable without a high level of outside input; 3) Assumed use or use support by donors may result in less attention by the CPS in the maintenance of a good survey and ground control system.

The Senegal CPS has been provided with a variety of fixed-wing aircraft (Cessna, Turbo Thrush) and helicopters (Allouette, Bell 206) by various donors for its aerial spray operations. According to the CPS, aerial control operations in Senegal have produced the following conclusions:

- large infested areas can be treated in a short time;
- inaccessible areas are more easily treated;
- aircraft logistical support is expensive, and large amounts of pesticides are required;
- pesticide drift is difficult to control;
- Landing strips for fixed-wing aircraft require frequent and expensive maintenance.

In light of these limitations concerning aerial control operations, the CPS policy is to use preventive ground control operations whenever possible. The components of ground operations are:

- training and equipping farmers and Village Brigades;
- early season egg pod surveys and localized destruction;
- increased survey and ground application teams.

3.5.5 Integrated Pest Management - IPM.

Integrated Pest Management utilizes all available control methods to achieve the most economically and environmentally sound management program. It is considered to be the preferred approach to pest control. IPM is not an alternative to the use of chemical pesticides; instead it is an integration of methods which may reduce use of pesticides by employing them more judiciously. Determination of intervention thresholds, correct timing of sprays based on pest population dynamics, and use of non-chemical control agents are among examples of modern and prudent pest management methods.

IPM can decrease pest losses, lower pesticide use, and reduce over operation costs, while increasing crop yield and stability.

Successful IPM programs have been developed for a variety of pests on various crops. Specifics of an IPM program will depend on the crop, cropping system, pest complex, economic values, social conditions, availability of personnel, and other factors and constraints. The following steps illustrate the development of an IPM program.

Step 1: Identify the Major Pests, and Establish Intervention Thresholds.

Dozens of potentially harmful species may infest a crop. However, only a few pest species cause substantial crop loss. The pests which recur at intolerable levels on a regular basis are known as primary pests, and are the focus of IPM programs.

The criterion that determines whether taking action to control a harmful species is profitable is called the intervention threshold (or economic injury level). The intervention threshold is the point above which control actions should be taken, and below which no actions are necessary. The economic injury level may be expressed in different ways depending upon the crop and the pest.

Examples of injury level indicators could be:

- Numbers of insects per plant.
- Percentage of fruit damaged by a given pest.
- Numbers of weeds per square meter.

Several factors will influence the intervention threshold for a specific pest: crop variety and stage of development, value of the crop, presence of natural enemies, cost of control measures, as well as external costs to health and the environment. The intervention threshold depends on the relationship between the pest intensity and the yield loss, and the economics of reducing the damage. It will therefore change as these variables change. The intervention threshold developed in one area will not likely be appropriate for use in another area.

Research is needed to determine the initial intervention threshold. This should be thoroughly tested in actual field conditions to verify effectiveness. The level can be refined as more information becomes available, and as it is used in the field.

Step 2. Select the Best Mix of Control Techniques.

All pest management methods and practices should be considered for an IPM program. First consideration should be given to use of preventive measures:

- Resistant crop varieties.
- Biological control (conservation or augmentation of natural enemies already present or introduced)
- Cultural control (cultivation, crop rotation, use of pest-free seed and planting stock, fertilizer management, and intercropping)

Farmers will likely already be using one or more of these preventive measures. It is therefore important to talk to the farmers before determining which measures are needed.

Pesticides should be used only if no practical, effective, and economic nonchemical control methods are available. Once the pesticide has been carefully chosen, it should be applied only to keep the pest below the intervention threshold. Pesticides will impact other organisms besides the pest, and may cause harm to humans, livestock, honey bees, natural enemies, and the natural environment.

Step 3: Monitor the Fields Regularly.

The growth of pest populations usually is related closely to the stage of crop growth and weather conditions. However, it is difficult to predict the severity of pest problems in advance. The crops must be inspected regularly to determine the levels of pests and natural enemies, and crop damage.

CPS survey personnel and agricultural extension agents can assist with field inspections. They can train farmers to separate pests from non-pests and natural enemies and to determine when crop protection measures, perhaps including pesticides, are necessary.

Step 4: Use All Control Methods Correctly and Safely.

Each pest control method has both advantages and disadvantages. CPS and Extension agents should learn as much as possible about each control method. Education programs should be developed to teach farmers how to use the available control methods safely and correctly.

Step 5: Develop Education, Training, and Demonstration Programs for Extension Workers.

Implementation of IPM depends heavily on education, training, and demonstration to help farmers and extension workers develop and evaluate the IPM methods. Hands-on training conducted in farmers' fields (as opposed to a classroom) is a must. Special training for extension workers and educational programs for government officials and the public are also important.

Integrated Pest Management (IPM) is a sensible approach to pest control whereby all existing control methods (pesticides, biological control, cultural control), mitigating factors, environmental concerns, climatic conditions, and ecosystem inter-relationships are integrated to assist in control operation decision making. While pesticides are part of the total IPM strategy, other methods are considered, with the choice dependant the methods that most closely fits the situation. Timing of pesticide application is an important factor in IPM, with the early season approach favored because of the low amount of pesticides utilized. IPM is not a pest control method itself, but rather, a way of considering options available in light of the physical and biological environment.

3.6 Pesticide Management

While there are many methods of g/l management, the method most commonly used is chemical pesticides. While pesticides kill pests, they also affect other living organisms in the ecosystems in and around cropping areas. In addition, misuse or overuse of pesticides results in higher overall operational costs. This is not only because of the direct cost of the pesticide, but also because of reduction in natural enemies in the crop ecosystem. The possible impact of pesticides on the environment and associated health risks to humans makes the way pesticides are selected and used, an important aspect of management programs.

To use a pesticide in a specific area at specific time, it is necessary to have detailed knowledge of the physical and chemical attributes of the product, the ecology of the area to be treated, and the biology of the pest to be treated. Pesticide selection for locust/grasshopper control requires the following concerning the pesticide itself:

- Effectiveness at low application rates;
- Minimal effects on nontarget organisms, including people and animals, and specifically predators and parasites of locusts and grasshoppers;
- Minimum persistence of residues on and in native fauna and flora, water, soil, and crops;
- Low toxicity and ease of handling;
- Good storage capacity;
- Compatibility with existing application equipment.

3.6.1 Pesticide Selection and Distribution

Although a number of pesticides have been used in Senegal against locusts and grasshoppers in the past, any pesticide involved in an operation funded by the USG must be approved for use in the United States by the EPA. Several approved pesticides are listed in the PEA, and should be referred to during both the planning and implementation of phases of l/g control management. In addition, regulations governing the use of a particular pesticide, as set forth of the label, must be followed.

Malathion, acephate and the three synthetic pyrethroids (cypermethrin, lambda-cyhalothrin and tralomethrin) are among the pesticides preferred for use in terrestrial ecosystems. For use near aquatic ecosystems (in all cases with the possibility of contamination of water), acephate would be the pesticide of preference from an environmental standpoint but efficacy is limited. Carbaryl, suggested by the PEA, is toxicologically acceptable but is more difficult to use than some of these other pesticides and is very toxic to bees. Diazinon and chlorpyrifos

are registered for use; potential environmental problems indicate they should be used with caution. Fenitrothion should be used only with extra precautions and with mitigative measures. Water resources are scarce in Senegal and should be protected from pesticide contamination as much as practicable. Therefore, the pesticides preferred for terrestrial use should be the ones favored for A.I.D. procurement. Chlorinated hydrocarbons, such as dieldrin and lindane, are not acceptable for use under any conditions, due to their environmental persistence, bioaccumulation, and acute toxicity.

Pesticides in Senegal are procured through three major supply sources: manufacturing and formulation by local companies representing foreign agro-chemical firms; imports by major multinational chemical companies; and donations from the international community. The CPS is responsible for maintaining and distributing pesticide stocks through centers in Dakar, Saint-Louis, Kaolack, and Tambacounda. Distribution takes place prior to the agricultural season, so all key management elements are prepared for any level of infestation. Pesticides are further distributed to villages, where central committees, trained by CPS, control subsequent distribution to farmers and smaller villages. The villages can keep excess pesticides for next season's use or they can return them to CPS. This distribution of pesticides by the government constitutes a system of subsidy that may encourage more use of pesticides than is necessary. Pesticides are also distributed commercially in the private sector, often with substandard or non-existent labelling. Dakar is also the commercial distribution center for pesticide supplies for surrounding countries.

3.6.2 Pesticide Labeling

Pesticide labeling is a way to give important information to the pesticide user. The label is the main and often only medium for instructing users in correct and safe use practices. Part of the labeling process is pesticide registration by host countries. Both registration and proper labeling require good solid legislation at the national level. It is important that the GOS draft legislation on Approval and Control of Pesticides, including a legal framework that will require pesticide labeling and registration in Senegal. A strong licensing and labeling program by the GOS would be an important step in achieving safe use of pesticides.

The pesticide product label can be effectively used to communicate a number of important properties of the pesticide and precautions appropriate to its use. In addition to directions for use, the label should include needed protective measures, first aid

measures, precautions recommending against use in certain environments, methods of container disposal, and application rates for particular pest species.

Pesticide labeling in Senegal tends to be quite variable. In general, pesticides in the original container carry a label with adequate information for application. Some labels, though not all, contained some information on first-aid or disposal. Unfortunately, much of the CPS stocked pesticide containers have either lost what labels did exist, or were rended illegible through handling and exposure.

While labeling must be specific to local needs and the social environment of Senegal, the FAO has prepared a global set of guidelines which can assist a labeling program. In addition to enacting legislation, the GOS should insist that donated pesticides be labeled in comprehensive language as required by donor country law, and be in French and English.

3.6.3 Managing Pesticide Stocks

A well maintained and secure pesticide storage facility is required for a U.S. pesticide donation. With a good pesticide management system in place, both donated and purchased pesticides can be controlled and utilized as needed. A good storage area should have a fenced and covered area for the pesticides. A pesticide storage warehouse should:

1) be isolated from dwellings in order to avoid fire, leakage, and water contamination;
2) be supplied with water in order to clean spills and fight fire; be aerated to avoid toxic fume concentration;
4) have a current inventory of pesticide stocks;
5) have protection gear such as suits, boots, gloves, goggles and breathing masks;
6) have a first aid kit with antidotes;
7) be staffed with trained personnel who are familiar with measures to take in cases of poisoning.

A management system is needed to record the date each pesticide arrived at the facility, how long it stays in storage, and when it is removed for use. In addition, the storage requirements for each pesticide must be posted and known by the management staff. Stored pesticides must be tested periodically to insure that the active ingredient is as described on the label, and that the formulation concentration is correct. Also the disposal of unused and obsolete pesticides, and the destruction of their containers, must be part of the management system.

Success of locust and grasshopper campaigns depends on availability of pesticides in the areas which need treatment.

Pesticides should be placed in safe and secure storage area as close as possible to agricultural areas which will likely need treatment. In Senegal, pesticide storage areas are associated with the CPS Operations Bases and Field Posts. At the CPS Operations Bases, a monthly inventory of products and materials should be made and sent to the Crop Protection Service in Dakar. Distribution of products to Bases is done according to need and severity of the locust/grasshopper threat, as well as the degree of isolation during rainy season. Pesticide stocks must be securely in place at Bases and in villages before the rainy season.

For the most part, the storage facilities in Senegal are good. Most of the CPS warehouses have been constructed within the last five years. However unwanted stock accumulation is a very real problem, as discussed below. A lack of planning and coordination has resulted in stockpiles of pesticides at some Bases, and shortages at others. This seems to be a result of a lack of training in the managerial aspects of pesticide storage.

Storage centers maintained by CPS are believed to be safer than storage in villages. Therefore, excess pesticides should be returned to CPS at the end of each treatment season. Simple storage safety measures for the smaller villages, such as keeping stocks secured and out of the weather, posting warning signs in the local languages, and preventing storage of pesticides in living quarters should be required and monitored by CPS.

Though undoubtedly better than village storage areas, the maintenance of pesticide stores by CPS could be improved. The central store near Dakar showed evidence of some good maintenance practices. Much of the stocks were on pallets to minimize manual handling, all were stored under a roof, and most of the containers had their integrity intact and were labeled either on the container or the stack or both. However, many of the containers were exposed to direct sunlight and/or were in poor condition, pesticide was spilled in the open on bare ground, some conflicts existed in the labeling, and some stacks of pesticides were not on pallets and/or were against back walls where "first-in first-out" would be difficult.

In addition to management of the pesticides themselves, the CPS Field Bases must adequately manage pesticide application equipment. Due to inconsistent donor contributions, Senegal has accumulated several different types and brands of spray equipment. This equipment is rarely interchangeable or compatible in regard to spare parts and repair. Nevertheless, the CPS Field Base must work to maintain what equipment it does have, and ensure that it is clean and in good working order.

This SEA recommends that CPS improve its pesticide storage practices. Among the changes that should be instituted are: 1) use pesticides in damaged drums first and handle drums more

carefully in the future so they will not become damaged; 2) do not accept any unlabeled containers; 3) store all containers on pallets away from the walls, label batches with date-in and planned date-out, and practice "first-in-first-out; 4) impose more rigorous handling practices to prevent spillage; and 5) install a sun shade to minimize direct exposure of containers to the sun. These practices should apply to all storage areas.

3.6.4 Obsolete Pesticides and Containers

Once the pesticide has been used, the management operation is left with an empty container. This container can be either reused or destroyed. If reused it should be only be used for the same pesticide or to store fuel. In addition, it can be flattened for use in construction. It should never, repeat never, be used to store water or food. Even though the pesticide is gone, enough is left to cause mild poisoning cases, especially in the very young or old. Further, small quantities of pesticides will make the human body more susceptible to other diseases.

While the CPS has an overall well managed pesticide stock system, most Field Bases have some storage problems, usually due to the accumulation of pesticide stocks which were not used in the prescribed season, or chemicals which have been banned and cannot be used. In many cases, containers are deteriorating, and pesticides has leaked into the environment, necessitating either repacking or disposal.

Empty pesticide containers reportedly are refilled with pesticides, reused by the petroleum industry or are split open to be used for roofing or other construction material. This SEA recommends that containers be primarily recycled for reuse in pesticide formulation. The use in construction and for other high human contact uses should be strongly discouraged. To facilitate proper reuse, container sizes should compatible with reuse requirements. Small containers (i.e., liter size) should be avoided, given the increased potential they present for use as cooking or water containers. In addition, CPS should periodically inspect the reformulation facilities to ensure proper handling and packaging.

The system of crop protection in Senegal, in which all pesticides are the property of the state, should theoretically result in effective management and disposal of empty drums. All containers belong to the government and should be removed from the field when empty. The Department of Agriculture is ultimately in charge of drum disposal. However, the reality of the situation indicates that training in this area could be useful.

3.6.5 Disposal of Unwanted Pesticides

Quantities of imported pesticides exceed Senegal's pest control requirements and the excess is shipped to neighboring countries. The distribution of pesticides to those countries which are critical breeding areas for grasshopper and locust species could benefit Senegal. Control of locust and grasshoppers in Mali and Mauritania may reduce the level of control activities and in turn reduce the quantities of pesticides used in Senegal.

When a pesticide is no longer needed, or is degraded chemically due to heat or time it will need to be disposed of. As the majority of the obsolete chemicals are liquid products, one disposal method is high-temperature incineration at a suitable facility. Incinerators in Europe or neighboring countries may also be used for disposal operations. Because of the current research in this area, and the potential for political ramifications, USAID/Senegal should consult AID/W prior to any pesticide disposal assistance program.

Senegal does not currently have environmentally sound pesticide disposal options. The CPS has stored 30,000 liters of dieldrin in Saint-Louis for 15 years. The CPS reports that this dieldrin is contained in 708 thirty liter containers, 97 fifty liter containers, and 214 two hundred liter containers. A preliminary study indicates that 9 of the two hundred containers are damaged and leaking. Disposal of this material is best acomplished by high temperature incineration. While incineration in a Senegalese cement kiln may be possible, this has not been fully assessed.

3.7 Cultural, Biological and Traditional Control Methods

Numerous non-chemical methods exist for pest management in general, and have been used against locust and grasshoppers. For example, crop varieties which develop at different rates from the commonly planted varieties, or which show resistance to insect attack may be applicable in the long-term. Sorghum, for example, is more resistant to attack by grasshoppers than millet. Other cultural methods, such as trap cropping, residue burning, trench digging in front of locust larval path, and intercropping may well have merit as well. Simple techniques such as using protected courtyards for tree seedling nurseries or covering seedlings with mosquito netting can be effective in small scale and limited cases.

Farmer experience with traditional or innovative control methods should be encouraged and incorporated into the overall l/g management program. If villagers can be recruited as participants

in control efforts, such as a Village Brigade, a field can be protected with a minimum of pesticide use and expense.

Research on field use of microbial agents in locust and grasshopper control is currently being implemented by A.I.D. and other international organizations. The microsporidian *Nosema locustae* has been tested in the US and in parts of Africa for its control potential. Preliminary results from Mali indicate that *Nosema* may be an unlikely candidate for use in an emergency situation, but could be part of an overall biointensive program. Additional work will be needed to determine its specific usefulness in an IPM context for longer-term maintenance.

In working with microbial pest control agents, attention must be given to handling and application techniques. *Nosema*, for example, has a short shelf life and must be used soon after production. In addition, the field climatic and environmental conditions will impact the microbial control agent.

Another research recommendation is the search for local and possibly more species-specific pathogens. Large population explosions of locusts/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 appropriate. Such a search should be done in collaboration with laboratories familiar with pathogen isolation.

Using Neem tree extract as an antifeedant has potential for being a component of IPM and may be appropriate for the northern regions of Senegal, where there are large numbers of Neem trees. Additional research on Neem is needed, especially in its use against locusts and grasshoppers.

Other fruitful research areas might include use of *fungal Beauvaria* spores and synthetic insect growth regulators. These types of agents are considered alternatives to conventional pesticides because of their different mode of action. However, there may be impact on non-target aquatic invertebrates.
Research on Non-Conventional Pest Control Agents

3.8 Safety and Health Care System

3.8.1 Public Awareness

In conjunction with A.I.D. assistance regarding locust and grasshopper efforts, it is important that the Government of Senegal monitor both human health and the natural environment. In regard to protecting human health, it is necessary to train both the medical community and pesticide applicators of the potential hazards of pesticides, and steps to mitigate. Application of a

pesticide in a given area should be preceded by public awareness and extension activities and education of the users. The Senegalese public must be informed that pesticides are dangerous and that empty pesticide containers should be not be used for food or water storage. A good public information program can include:

- information on the specific pesticides and labels;
- safe methods of pesticide transport and storage;
- measures in cases of container leakage;
- conditions for pesticide use;
- safe use of application equipment;
- prevention of pesticide poisoning.

Pesticide educational programs can be instituted by Health Engineering and Sanitary Service agents. Health education and extension programs can also provide information on first aid in pesticide poisoning cases. The inherent toxicity of used pesticide containers is an important subject area, and should be specifically directed to women who might use the containers for cooking or holding water. Components of a pesticide public awareness program should include photographs, posters, and prints on cloth. These should be given to agents as visual aids to hang on walls of schools, dispensaries, and on large trees in villages and towns.

Radio broadcasts are an important part of a public information campaign, including pesticide awareness information in the form of brief safety announcements, musical programs, interviews, debates, and dramas. Discussions of pesticide regulations and legislation should also be presented, including information on which pesticides are legal and which are prohibited in Senegal. This will allow potential buyers and users to know what pesticides should be accepted and what should be refused.

3.8.2 General Pesticide Safety Concerns

Because of the role pesticides can play in potentially increasing agricultural productivity, the Government of Senegal regards these chemicals a useful part of agriculture. Unfortunately, pesticides can be misused by both farmers and CPS agents, presenting hazards to the human environment and the natural ecology. Some pesticides in Senegal are marketed illegally and fraudulently. Pesticides intended for agricultural or public health purposes may be misused for fishing, hunting, and general household insect control.

In addition to the potential for unsafe application, pesticides may also affect public health by being stored improperly. It is important to keep stored pesticides in good condition, away from humans and other animals. Any unwanted or leaking pesticides must be repacked or disposed of as soon as possible. Because pesticides have the potential for misuse, it is essential that existing legislation on pesticide use be enforced.

While abuse may still occur, implementation of regulations will provide a sound base for promoting public health and environmental integrity.

3.8.3 Applicator Safety Training

A.I.D. has supported CPS pesticide safety training in the past, and will likely continue to do so. It is important that well trained CPS agents are available to work with any U.S.-funded pesticide donation.

The incorporation of hands-on pesticide safety and application training courses into the academic course in agronomy and other agricultural degrees is essential. This approach will allow trained individuals to interact with the actual users of pesticides.

Properly trained CPS agents and agricultural extension agents are encouraged to work with farmers and Village Brigades in "Train-the-Trainer" programs. This type of training will allow essential information on pesticide safety and application to reach all who may be working with pesticides. This type of training is strongly encouraged by A.I.D..

An additional approach is an emphasis on pesticide safety training among private suppliers of pesticides. Senegal is an affiliate of several pesticide organizations, and would likely work well with the private sector in ensuring the correct use of imported pesticides.

3.8.4 Public Health Care System

The public health delivery system in Senegal is fairly well developed and includes regional Postes de Sante, each staffed with a nurse. The Postes de Sante are the lowest level of the health care system where pesticide incidence could be handled. This level of infrastructure should be provided with information materials on the pesticides used in the area. The personnel of these centers should be given the necessary training to recognize and treat pesticide poisonings. Information is available in the EPA handbook on pesticide poisonings (Morgan, 1989).

Primary health care is delivered through a network of health centers and village health posts. Health centers are located in most of the larger towns, and can include some maternity and inpatient beds. For village health posts, communities contribute resources and build health units out of local material. Community Health Workers are trained at a subdivisional hospital. Full service hospitals offering specialty care are located in the

provincial capitals. General hospitals which do not offer specialty services are located in divisional and subdivisional capitals. Tertiary care is available in Dakar

Senegalese medical personnel are generally aware of the harmful effects that crop protection products can have human health. The Crop Protection Service has been working closely with doctors and nurses since 1988 to increase awareness of the medical community to the hazards of pesticides and symptoms of exposure. In 1988, the Ministry of Health distributed a special pamphlet with pertinent diagnostic and control information on pesticide exposure to all health workers The local health care delivery system in Senegal may not be equipped to handle a serious case of poisoning, which, if it occurs, is most likely to involve an applicator. Therefore, application crews need to be self-sufficient in handling medical emergencies. Supervisors must be familiar with safe handling of pesticides and be able to administer any needed first aid, including antidotes for pesticide poisoning. All who are working with pesticides should be familiar with the early warning signs of poisoning. Workers must be removed from contact with pesticides at the first signs of poisoning.

3.8.5 Potential for Human Health Impact

The potential for adverse human health effect increases significantly when pesticides use is high. When large areas of the country are treated and large amounts of pesticide products are being shipped, distributed, and applied, the probability of exposure of humans (and the environment) is proportionately greater. This SEA advocates prevention of human exposure as the best approach to minimizing adverse health impacts. A major aspect of prevention is to keep grasshoppers at low population levels with preventative control strategies, as discussed in the previous section. Another major aspect, covered in this section, is prevention of exposure.

3.8.6 Prevention of Human Exposure

The general population is most effectively protected from any adverse health effects by proper pesticide application techniques. Whether or not the application is safe for the general population depends on the toxicity of the pesticide, the formulation used, the concentration of the pesticide in the formulation, the frequency of application, the kind of equipment used, and the training of the applicators in safety precautions. In areas of highest population

densities, treatment-free perimeters can be observed in order to avoid exposure.

This SEA advocates training, educating, and supervising the applicators as the most effective way to ensure that exposure of the general population is kept at or below an acceptable levels. Such 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.

The general public is at minimal risk if the necessary precautions are taken, but should nevertheless be informed about pesticide use. This can be achieved by a number of means, such as posters, the radio, and local news papers. Public health advisories given by radio broadcasts were effective in Senegal prior to past aerial applications and should be included in plans for future applications. This is especially important in areas where locust consumption might occur. It also should include public education about the dangers of improper pesticide container reuse.

Pesticide applicators are generally at the highest risk for any adverse effects, and are several orders of magnitude higher than the general population since they are handling concentrated products. In addition to the training and supervision indicated above, applicators should be thoroughly familiar with the level of danger from the pesticide, and should be provided with equipment that is in good working condition in order to minimize accidents. Such equipment may include pumps to transfer pesticides, body protection in the form of gloves, aprons and safety shields for the face to prevent dermal exposure and respirators to prevent inhalation.

It is particularly important that some form of protection is worn during the short periods while handling the concentrates. If at all possible, long sleeved shirts and pants should be used, and frequently washed. CPS logos or patches on the protective clothing items can help to induce use and care.

Exposure of applicators is mostly through the skin. Though the skin usually provides a significant barrier to the entry of some pesticides, even those penetrate into the body if the contamination is left on the skin. In addition, some pesticides penetrate the skin more readily. Therefore, applicators should wash any exposed areas of their bodies frequently. If water is scarce, the wash water could be saved for use in diluting pesticides.

3.8.7 Monitoring of Human Exposure

Simple and effective health monitoring of those involved in pesticide handling, application, and storage is essential to a good management operation. This involves teaching all involved with pesticides what the symptoms of pesticide poisoning are, and when first-aid might be required. It is especially important to use behavioral observation to decide if workers should be immediately removed from pesticide exposure.

The GOS should have the capability to monitor both behavioral symptoms of pesticide poisoning, and such blood-chemistry manifestations such as acetylcholinesterase (AChE) inhibition. Testing for AChE inhibition is fairly simple and inexpensive, and can be performed by trained health workers in the field. The background cholinesterase level for each person involved with pesticides must be determined prior to exposure, and testing should be performed at intervals throughout the season to ensure that no worker is being overexposed to pesticides. Testing AChE is recommended only when pesticides in the organophosphate class are used.

Measurement of residue levels in the environment can also be a valuable source of information for assessing exposure and determining if modifications to treatment operations are needed. The University of Dakar has a well functioning chemical residue laboratory which could measure actual residues deposited in residential areas due to pesticide spraying. In addition, the GOS/CPS is presently equipping an analytical chemistry laboratory. The environmental residue data produced by these laboratories, including residue data on food and feed items, can be a reliable, relevant and accurate way of monitoring environmental impact.

3.9 Environmental and Non-Target Impact

3.9.1. Environmental Impact Minimization

Due to their toxic nature, pesticides will impact both crop and nearby ecosystems. Care must be taken during the handling, transport, application, and disposal process to insure that as little impact as possible is allowed in non-target areas. In addressing this issue in regard to operational planning, risks to the environment must be considered in terms of early season management, versus late season large scale operations. The latter would involve considerably greater amounts of pesticide, and therefore a correspondingly higher risks.

Because of the additional risks incurred in late season control operations, USAID/Senegal supports management operations designed to avoid such risks. Early season survey and management can prevent late season control operations, with significantly less pesticide usage. Preventive management operations with attention on survey operations aimed at locating and delimiting pest populations, and spot treatment operations intended reduce population numbers using as little pesticide as possible are favored.

By reducing the number of hectares sprayed, early season control operations use less fuel, reducing vehicle wear, causing vehicles to last longer. Because early season control strategy uses considerably less resources, the CPS is better able to implement without donor assistance. This will allow a greater degree of self-sufficiency and control of the situation by the CPS itself.

If pesticide use is necessary, the type of ecosystem in the treatment area, and associated non-target species, should be major factors determining the choice of pesticide. A pesticide's characteristics, such as selectivity, mobility in ground water, persistence, and metabolic products should be considered as important as effectiveness against target species. In addition, application methods should be considered, with ground application having less impact than aerial treatment.

The response of different animals and ecosystems to pesticide exposure varies dramatically. For example, carbaryl has only low toxicity to birds, but is extremely toxic to aquatic invertebrates and certain estuarine organisms. While application of carbaryl may be appropriate in areas providing upland habitat for birds, its application in areas important to waterfowl and migratory shorebirds, such as National Parks or Reserves in Senegal's coastal and riverine areas should be prohibited.

Although this SEA strongly recommends against any pesticide applications in aquatic systems, acephate is relatively nontoxic to freshwater fish and invertebrates and is the least likely of the selected pesticides to have adverse effects on aquatic habitats. Acephate should be one of the preferred pesticides if applications are necessary adjacent to aquatic systems, particularly when threatened or endangered species, such as Senegal's five species of crocodiles, five species of sea turtles, the manatee, or the sousu may be affected. Due to its mobility in soils, however, acephate has the potential to contaminate ground water. The application of acephate to areas providing rapid recharge to ground water fed bore holes in Sylvo-Pastorale Reserves (used by livestock and native animals) and domestic water supply wells should be avoided.

3.9.2 Environmental Monitoring

Part of the overall pest management system is monitoring treated areas for potential environmental effects of pesticides. Monitoring can indicate negative impacts on flora and fauna, as well as detect improper application methods which can impact human health and increase operations cost. Measuring pesticide residues in the environment is an excellent way of monitoring, and will require a residue analysis laboratory for full implementation. Pesticide use support should incorporate residue analysis into project plans, and should include qualitative behavioral observations of non-target organisms near any pesticide target areas. CPS applicators must be trained to note unusual behavior among fauna of the area.

Although monitoring is likely to produce variable results, it can be a valuable feedback tool in control operations. It can provide some general conclusions on effects and can be used in designing modifications of pest management activities. Given the large number of variables that can affect results and the limited resources likely to be available for monitoring, using mortality and population counts, and behavior observations may be the most practical ways to assess the effects of pesticide applications. Baseline conditions for an indicator species and its habitat should be determined prior to pesticide application, and post-application monitoring should be conducted at intervals sufficient to allow assessment of both immediate and long-term effects. It is also important to select species with demonstrated sensitivity to pesticide exposure. The complete report of the FAO study of nontarget effects in Senegal, when it is available, should indicate the relative sensitivity of various types of organisms.

Aquatic habitats are often critical habitat to sensitive species and migratory birds. Therefore, pesticide use near such habitats should be avoided wherever possible. Care must especially be taken when pesticides are applied during or close to the time of seasonal rains. This may lead to introduction of the pesticide into water supplies or aquatic systems in runoff. Because invertebrates are generally much more sensitive to insecticides than vertebrates, monitoring the observable effects of pesticide use on invertebrates, such as benthic organisms, should be the preferred method for monitoring aquatic habitats. Vertebrates, however, should not be ignored, as pesticides effects on them may be indirect, but no less severe.

A similar monitoring approach should be used for pesticide use in terrestrial ecosystems. Selection of soil microorganisms or other low tolerance invertebrates as indicator species is recommended. Monitoring animals of economic value or threatened status should also be required. In cases where pesticide persistence is an issue, residues should be measured. Populations of vertebrate predators, such as birds of prey, are likely to

fluctuate too much to make population counts an effective monitoring tool. However, reproduction monitoring of carnivores (e.g., observations of egg conditions, birth defects, infant mortality) may be a useful tool in determining the effects of pesticides known to effect reproductive success, particularly in cases where baseline data are known.

4.0 PROTECTED AREAS/PROTECTED ANIMALS AND PLANTS

Because pesticides will impact both crop and natural ecosystems, a system of natural resource protection is necessary. This can be accomplished by setting aside areas and zones where pesticides are not used, or severely restricted. Endangered animals and plants need to be taken in to consideration in regard to habitat intervention. Since birds and fish are particularly vulnerable to the direct and indirect impact of pesticides, these organisms need to be given special respect. Some areas should be set aside to be protected from pesticide use no matter how great the perceived pest control need.

Protection of animal and plant species and their habitat preserves regional biological diversity. In addition to protecting habitat and inherent existence value, Protected Areas also provide a safe place for reproduction and regeneration of wildlife after losses from drought and poaching (especially, Gueumbeul and fish spawing areas in estuaries). They provide for a non consumptive use industry (tourism) which, because it is non-consumptive, has a very high return value. In addition, protected plants may hold value for future industrial and pharmaceutical use. Protected areas can also contribute to local village economy through value-added income. An indepth coverage of this subject has recently been completed in the report entitled "Senegal Natural Resources Management Assessment", prepared by Grosenick, et al., published for A.I.D. in June of 1990.

4.1 Protected Animals and Plants

4.1.1 Animals

Overall, there are thought to be about 92 genera and 175 species of mammals, and 542 different types of birds, and 240 species of freshwater and estuary fish from 22 families in Senegal. The number of insect, reptile, amphibian species is thought to be equally diverse. Many species reach their northern of southern limit in Senegal.

Sixteen animal species are listed as endangered or threatened in Senegal with another eleven listed as vulnerable or rare (Table 3). Areas with threatened or endangered species and critical habitats should be considered to protection (banned, restricted, or allowed for preventive purposes). Protection designation will allow protection not only form pesticide use, but other potentially negative impact activities.

Table 3. Threatened and Endangered Animals in Senegal (Shaikh, 1988)

Extirpated

Giraffe
Korrigum hartebeest

Endangered/Threatened (Red Book)

Chimpanzee
African wild dog
Giant (Derby's) eland
Manatee
White-collared mangabey
Pangolin
Sousa
Cheetah
Leopard
African dwarf crocodile
African slender-snouted crocodile
Green sea turtle
Kemp's (Atlantic) Ridley turtle
Hawksbill sea turtle
Leatherback sea turtle
Loggerhead sea turtle

Vulnerable (locally endangered) or rare

West African elephant
Western Red Colobus monkey
Black-and-white Colobus monkey
Cape Clawless otter
Aardvark
Pangolins
Red River hog
Ostrich
Nile crocodile

While protected animals are covered by several Senegalese laws and regulations, enforcement is usually lax to non-existent. The listed endangered and threatened species have been noted to continue to decline despite legislation. Several animal species will likely cease to exist without considerable higher level of protection. Any U.S.-funded operation must consider the potential impact of pesticides on these already strained animals. While human life cannot be placed below that of an endangered species, the U.S. should not allow itself to be drawn into a situation that may force such a choice. Here again, early survey and surgical treatment programs can allay such situations.

4.1.2 Protected Plants

There are over 2,100 types of plants in Senegal. While some limited legislation exists to protect rare or unique species, most plants are protected only by local traditions and customs. Several species have been added to the endangered list due to development projects. Included in this category is Echinochloa stagnina, whose survival is threatened by irrigated agriculture projects along the Senegal river. Pesticides can impact plants by removing pollenators and inducing a secondary pest situation.

4.2 Protected Areas

There are about 184 classified forests and sylvopastoral reserves in Senegal, covering over 2,773,595 ha. Senegal administers national parks which include most of its major biotic communities. This includes four national parks for the protection of wetlands and migratory birds. Additional "protected" areas include several forest/pastoral reserves, nature reserves, and a hunting zone. A total of 23 areas are included in these various "Protected Area" designations.

Protected areas should be surrounded by a buffer zones at least 2.5 km wide. These are needed to avoid accidental pesticide application and possible spray drift, and to will help to minimize indirect effects of pesticide use. Within buffer zones, a higher priority should be given to the use of alternatives to chemical pesticides, and a monitoring program so that non-chemical alternatives can be applied successfully. As the capacity of the CPS to provide training in non-chemical alternatives increases, the width of the buffer zones can be increased.

This SEA supports the establishment of 2.5km buffer zones around water bodies and areas containing endangered species and

critical habitat. The Protected Areas in which pesticides should be banned includes the following environmentally sensitive areas:

Wetlands areas	----	the delta area below Kaolack and the wetlands area inland from Saint-Louis
National parks	----	Niokolo Koba, Djoudj, Sine-Saloum Delta, Lower Casamance, Gandiol, and Langue de Barbarie
Wildlife areas	----	Ndiael Bird Preserve, Ferlo Faunal Reserves
Reserves	----	Palmarin, Abuko Nature

Given the importance of biodiversity in these habitats (see Figure 3), locust and grasshopper control adjacent to buffer zones surrounding them should be limited to the pesticide with the lowest potential for impact on non-target species and with acceptable efficacy for the target species.

In addition, pesticide use in most of the other national parks and reserves (including , Niaye de Sangalkam N.P., Ile des Madelaines N.P., Ile de Goree N.P., and Faleme Hunting Zone) should be avoided if possible. These areas are not expected to be significant sources of massive populations of locusts or grasshoppers and could serve as reserves for native pathogens or predators of locusts or grasshoppers.

The Ferlo Reserves (North and South) and GOS designated Sylvo-Pastorales should have pesticide use allowed to the extent it is consistent with other management objectives of those areas. Such use should be primarily for preventive purposes; when locusts or grasshoppers are widespread in other parts of Senegal, these reserves should be left untreated. Additionally, bore holes in several of these areas provide water to livestock and native species. The buffer zones given by recommendation # 6 of the PEA should be observed for these areas.

The Sudanian Zone has the significant legal protection in Niokolokoba National park. But, not all Sudanian woodland types can be found within the park. For instance, the Classified Forest of Patako-East (Kaoalack) has been suggested as a site for upgrading and increased protection because it has an extraordinary variety of tree and Combretum species. Similarly, the relict Guinean Park providing adequate protection for a few of the existing "Guinean" vegetation types. The Classified Forests of Dianteme and Essikene have received attention from IUCN and the Sweden. But, biological status of the forests is unknown.

The Zone Integralement Proteges have about the same protection level as American National parks. Both flora and fauna are protected by virtue of Senegalese and international conventions and treaties. Partially protected areas allow certain uses such as grazing or human habitation. These areas are usually considered game reserves in that hunting is prohibited. The most important is Ndiael which is also part of the RAMSAR international protection program.

Senegal has three major rivers (Senegal, Sine-Saloum, Casamance) flanked by remnant gallery forests and wetland habitats. The Gambia River and its tributaries also provide valuable riverine and wetland habitats which extend into Senegal. Guiers Lake is Senegal's only major permanent body of water, but numerous temporary pools and lakes utilized by waterfowl, wildlife and livestock are found in the Ferlo Valley. Pesticide use should be banned, restricted, or accompanied by conservative protection measures near these water bodies.

The inland wetlands which are protected include: DJoudj, Sine-Saloum, Kalisaye, Kassel, Popenguine, Ndiael, and Guembeul. The actual state of protection of walos, floodplains, bourgoutieres, sloughs, bolons, and marigots need a much better review than presently exists. The coastal biological resources also have significant legal protection (Basse Casamance, Sine Saloum, Iles de Madeleine, Popenguine, Kalisaye, Kassel, Langue de Barbarie). No review of coastal islands (especially those near Gambia) and pristine coastal strand communities is known to exist.

The implementation of fragile area protection programs must lie with the GOS itself. Enforcement of regulations to ensure sensitive areas are actually protected is to the ultimate benefit of the people of Senegal, and must therefore be made a priority. The effectiveness of protection programs is closely linked with integration of local populations to build a feeling of responsibility. Donors should monitor the protection program, assisting if necessary, and may wish to base funding levels on the level of GOS commitment for environmental protection.

4.3 Pesticide Alternatives in Sensitive Areas

Farmers living in areas which have been designated as environmentally sensitive should receive training in IPM and the use of control methods which do not use chemical pesticides. These farmers should be encouraged to use traditional methods and should be informed as to how pesticides are dangerous to both humans and the environment. Farmers in such areas should be given individual attention, time to ask questions, and opportunity for discussion. CPS trainers should have a basic knowledge concerning food chains and the indirect effects of pesticides.

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APPENDIX A

LIST OF PREPARERS/CONTACTS

Government of Senegal

Seni Dieme, Crop Protection Service

Abdoulaye Kane, Ministere de la Protection de la Nature

Abdoulaye Niassy, GOS, Crop Protection Service, Dakar.

USAID/Senegal

James Bonner, Agricultural Development Office (former)

David Delgado, Agricultural Development Office

Djiby Diop, M.D., Health Consultant

Mamadou Ba, Agricultural Development Office

Mawa Diop, Agricultural Development Office

Gil Haycock, Environmental Officer

Moribadjan Keita, Agricultural Development Office

Rodney Kite, Agricultural Development Office (former)

Arthur Lagace, Health Population and Nutrition Office

Jean LeBloas, Irrigation, Water Management & Engineering

Gary Nelson, Deputy Director

Wayne Nilsestuen, Agricultural Development Office

David M. Robinson, Project Development Officer

USAID Washington

Bill Thomas, Entomologist
George Cavin, Entomologist
Reto Engler, Pesticide Scientist
David Powers, Environmental Specialist

APPENDIX B

PEA for LOCUST AND GRASSHOPPER MANAGEMENT
ANALYSIS OF PEA RECOMMENDATIONS

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 (IPM).

This recommendation should be applied in the context of the specific needs of Senegal. USAID/Senegal supports IPM in the management of locusts and grasshoppers, as well as other insect pests.

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.

This recommendation can be part of future USAID/Senegal involvement with assistance efforts. Maps should include specific areas to be protected, some with a total ban on pesticides for grasshopper or locust control and some with a high priority for restricted use of pesticides.

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

Because of past poor management practices in Senegal, large stocks of pesticide have been allowed to accumulate and degrade. In addition, stored pesticides are not always handled carefully or tracked to insure correct use and disposal. Improvements in the system for managing pesticide stocks must be implemented to protect human health and the environment and to minimize chances 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.

A plan for managing obsolete stocks has been drafted with the support of A.I.D. Washington. This should include the periodic testing of stored pesticide stocks to insure that the material is usable. Unwanted stocks in Senegal should be disposed of only with technology that best fits the local situation. High priority should be placed on minimizing the future accumulation of any unwanted 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.

This SEA supports that recommendation as an AID/W-coordinated activity.

MITIGATION OF NON-TARGET PESTICIDE EFFECTS

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

Any future spray operations or pesticide donations for use in Senegal should be accompanied by a requirement prohibiting use in some areas and limiting use in others and requiring appropriate buffer zones. The areas of total prohibition are designated wetlands, national parks, national forests, and fragile areas. Buffer zones and other reserves should restrict pesticide use, and encourage traditional and non-chemical methods. Villages, towns, cities, or any other human settlement will not be sprayed.

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

Pesticide recommendations in the PEA should be followed until research results indicate that more environmentally safe pesticides are available for use. Investigation of traditional and cultural methods of control are also strongly encouraged as a USAID/Senegal activity. This SEA does not contain a list of pesticides because it accepts the pesticide selection in the PEA.

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.

This recommendation should be implemented to some extent if possible, but may be difficult to fully implement in Senegal, due to both the expense and a lack of supportive infrastructure. A program of 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 target and non-target mortality, population numbers, and behavior should be made at locations involved in pesticides use.

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.

A number of operational procedures should be followed to minimize the area to be sprayed. 1) Emphasis should be on an early and vigorous surveillance program, thus allowing early treatment operations and reducing the amount of pesticide used; 2) Crop protection operations should utilize intervention (economic) thresholds to the extent possible; 3) A program of identifying non-treatment areas and minimum treatment areas should be adopted; 4) Training of all decision-making individuals should emphasize the importance of restraint in use of pesticides; 5) Farmers and villagers should be included in training and subsequent survey and application operations.

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 treatment program in Senegal should emphasize early season ground application. However, during rainy season treatment operations, road conditions may necessitate the use of aircraft. In addition, there are areas of Senegal which are inaccessible except by helicopter. The AID/W (Forest Service) Aerial Application Guidelines should be followed in any such operation.

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.

This SEA supports this recommendation. However, large aircraft may be needed in Senegal to spray areas far from supportive infrastructure.

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.

This SEA agrees with this recommendation. In addition, this SEA strongly supports both long- and short-term training to be integrated with USAID-provided technical assistance.

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

This SEA agrees with the recommendation and urges the GOS to give high priority to pesticide legislation and implementation of laws requiring a good clear label. It is suggested that the GOS follow the FAO pesticide label guidelines.

DISPOSAL OF PESTICIDES

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.

A.I.D. Washington is currently developing guidance on disposal programs for unwanted pesticides and empty containers. In addition, several pilot disposal projects are being implemented. USAID/Senegal should follow such disposal guidance when available, and should continue to assist with proper pesticide management. Proper disposal of empty barrels is especially important.

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 pesticides, environmental awareness, pest management techniques of locusts and grasshoppers, and the potential hazards of pesticides. The goal would be to enable policy makers and local populations to recognize and avoid potential health problems related to pesticide applications.

Collaboration between the CPS and other ministries, begun with the writing of this SEA, should continue with the development of public and applicator education on pesticide safety, pesticide poisoning recognition, avoidance, and treatment. In addition to receiving information on general pesticide awareness, the public should be made aware of the need to protect environmentally sensitive areas from pesticide misuse. Radio is an extremely effective medium in this regard, and should be utilized to its fullest.

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

This SEA supports this recommendation and advocates inter-governmental collaboration in training programs.

Recommendation 17. It is recommended that each health center and dispensary located in an area where pesticides are used be provided with posters describing diagnosis and treatment of pesticide poisonings, as well as medicines and antidotes required for treatment of poisoning cases.

This SEA supports this recommendation, and advocates collaboration between CPS and the Ministry of Health in appropriate implementation.

Recommendation 18. It is recommended that presently available tests for monitoring human exposure to pesticides should be implemented in the field. This includes measurement of cholinesterase levels in blood as a screening and indicator test for pesticide handlers and applicators.

This SEA supports the need to monitor the health of pesticide applicators and handlers during control operations. It is especially feasible to monitor blood cholinesterase in individuals working with organophosphate pesticides. This should be

implemented on a regular basis with pesticide handlers and applicators. In addition, this SEA favors behavioral monitoring for symptoms of pesticide exposure.

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.

This is an AID/W activity that should be implemented through a revision of A.I.D.'s Pest Management Guidelines, currently underway. No Senegal-specific recommendation is included in this SEA as it is a central and regional activity.

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

This is an AID/W activity that should be implemented through a revision of A.I.D.'s Pest Management Guidelines. A.I.D. is working with the EPA Pesticide Disposal Workgroup to achieve state-of-the-art pesticide container specifications.

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.

AID/W is currently supporting research bio-pesticides in Africa. 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. USAID/Senegal may support training and local research in this subject area.

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.

This SEA supports that recommendation for Senegal. The L/G Operations Handbook (A.I.D., 1989a) fills this need in part, as does the PEA and this SEA. Other materials include regional meetings and workshops, and short-term technical assistance.

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

This SEA supports this recommendation, and recommends that the high priority be given to training on the safe and appropriate application of pesticides. Training can take the form of courses, as well having as individuals work with outside technical expertise. "Train the trainer" programs are especially effective in passing information with minimal expense.

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.

This SEA supports that recommendation as an AID/W activity. The overall preference is to have technical assistance teams with the needed technical expertise and sufficient language fluency for the tasks to be performed.

ECONOMICS

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

This SEA supports this recommendation. Implementation in Senegal might consist of an agricultural productivity analysis

along with an annual agricultural database program. This should include a research study on crop loss analysis.

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

Due to the erratic nature of these insects, along with potential for social impact, a valid intervention (economic) threshold will require both the long-term collection of quantitative data, and research to determine the extent to which agricultural productivity is threatened. In this light, it is important that intervention decisions, especially those involving pesticides, 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 registration and management of pesticides and the drafting of environmental policy.

This SEA supports that recommendation. AID/W and EPA are developing an assistance program to assist with pesticide regulations and policies, including human safety, environmental impact, and use, storage, and disposal. Implementation should include improvement of pesticide labeling, including clear precautionary statements, specific use directions, and appropriate instructions for disposal of empty containers. In addition, policy must include an environmental monitoring program, with results used in the planning of future pesticide use operations, as well as detection of possible misuse or unexpected adverse results.

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.

This SEA supports that recommendation, and considers this to be a topic appropriate for GOS action. Such a pesticide inventory program, done in conjunction with good storage management, can prevent the build-up of obsolete stocks, and thereby reduce overall operations and storage costs.

PESTICIDE HANDBOOK

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

This SEA supports that recommendation as an AID/W or REDSO activity. Among the relevant activities in this area are A.I.D. policies concerning pesticide use, efficacy and agricultural productivity, environmental impacts and health effects, and safety and mitigative measures. The Handbook should contain health, safety, and environmental assessments of pesticides that are likely to be used in Senegal.

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.

This SEA supports this recommendation, but only with a through analysis of actual needs, existing supportive infrastructure, and the ability of the CPS to manage a sustainable program.

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.

This SEA supports this recommendation, and considers this a valid activity for Senegal. Due the inadequate storage facilities that currently exist in Senegal, support is for the Pesticide Bank concept. A through evaluation of storage facilities should be completed prior to project assistance.

FORECASTING

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

This SEA is in favor of continuing and improving forecasting as an AID/W or FAO activity.

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.

Although this is a valid activity for Senegal, a lack of supportive infrastructure would require that such a research program be accomplished with outside expertise and facilities.

RESEARCH

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

This SEA supports this recommendation, including the search for other microbial pathogens of locust and grasshopper species as a longer term priority.

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

Neem may be one of the most promising new bio-pesticides, and thus deserves additional field research. As additional funds are available, the most promising options should be pursued. If Neem extract shows promise, research efforts should continue.

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.

This SEA considers such comparative impact research an appropriate AID/W activity. A major international research effort has been launched in Senegal on the ecotoxicological effects of locust insecticides.

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.

This SEA supports this 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 Burkina Faso, Cameroon, Chad, Mali, Mauritania, Niger, Senegal, and Sudan. 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 Senegal has been developed by the CPS. The country-specific

plans of action will be the backbone for guidance of locust/grasshopper control activities.

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.

This SEA supports this recommendation. Coordination must occur both at the AID/W level and the USAID/Senegal level. In Senegal, 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. Relevant Documentation.

FAO Pesticide Management Documents:

a) International Code of Conduct for Distribution and Utilization of Pesticides.

b) Guidelines for safe pesticide distribution, storage, and handling.

c) Guidelines for pesticide disposal and container disposal.

d) List of FAO approved pesticides.

e) Pesticide storage and packaging guidelines.

f) Guidelines for pesticide approval and management.

g) Ecotoxicological guidelines.

h) Ground and aerial application guidelines.

i) Insecticide poisoning: prevention, diagnosis and treatment.

j) Guidelines for effective labeling.

k) Efficacy requirements for pesticide approval.

Other Documents on Pesticides and Locust/Grasshopper control:

a) Guidelines for selection, procurement, and use of pesticides in World Bank-financed projects.

b) Crop Protection Service Organization (D.310) T. 1. PRIFAS. Dec. 1988.

c) Effectiveness of localized pesticide treatment. (D.309) T. 2. PRIFAS - Dec. 1988.

d) Effects of locust and grasshopper control on the environment. (D. 308) T. 3. PRIFAS - Dec. 1988.

e) Locust and Grasshopper Control - Interministerial Instruction No. 3 related to protection of man and environment. Algérien doc.- March 1989.

f) First aid in cases of poisoning by locust and grasshopper control products. CIBA-GEIGY.

USEPA Pesticide Fact Sheets:

Acephate	# 140	October	1987
Bendiocarb	# 195	June	1987
Carbaryl	# 21	March	1984
Cholpyrophos	# 37	September	1984
Diazinon	# 96.1	December	1988
Fenitrothion	# 142	July	1987
Malathion	# 152	January	1987
Lindane	# 73	September	1985

These are among the many Pesticide Fact Sheets issued by the U.S. Environmental Protection Agency, selected for relevance to locust and grasshopper control. They summarize data known to EPA at the time of preparation of the Fact Sheet. They generally include information on acute and chronic toxicity to humans and other non-target organisms, handling precautions, and other instructions for use. They may be requested from:

Office of Pesticide Programs
US Environmental Protection Agency
401 M Street, SW
Washington, DC 20460 USA

APPENDIX D. CASE STUDY OF LOCUST PATTERNS IN 1988

Several interviewees stated that locusts originate in Mauritania and Mali rather than originating within Senegal. That hypothesis was tested by studying the patterns of locusts in 1988, the recent year in which locust infestation was the worst in Senegal. The weekly Regional Desert Locust Bulletins from OCLALAV were examined for 28 July through 16 December 1988 (Nos. 2-8, 10-14, 16 and 18-21). The following is a summary of the portions of those reports that are relevant to the issue of the origin of locusts in Senegal.

28 Jul - 3 Aug 1988	Mauritania with some locust activity; Senegal not mentioned in report.
4 - 10 Aug 1988	Mauritania with some locust activity; Senegal not mentioned in report.
11 - 18 Aug 1988	Mauritania with heavy locust activity; Senegal reported to be "quiet".
19 - 26 Aug 1988	Mauritania with heavy locust activity; Senegal reported to be "quiet".
27 Aug - 2 Sep 1988	Southeastern Mauritania reported as "alarming"; Senegal reported to be "quiet".
3 - 9 Sep 1988	Mauritania and Mali with swarms of locusts; Senegal reported to be "quiet".
10 - 16 Sep 1988	Mauritania and Mali with swarms of locusts; Senegal reported to be "quiet".
24 - 30 Sep 1988	North and west Senegal invaded by copulating swarms of locusts.
1 - 7 Oct 1988	Western Senegal basin from Podor to Saint-Louis and Atlantic coast from Saint-Louis to Nioro-du-Rip infested: hatching of eggs in Rao.
8 - 14 Oct 1988	Casamance and Kedougou with swarms of locusts; 7,700 ha north of Ziguinchor infested; hatching at Saint-Louis, Lduga, Thies and Diourbel; egg laying at Fatick and Kaolack.
21 - 28 Oct 1988	Many immature swarms; further development of hopper bands in the north, along the coast and in central Senegal.

5 - 11 Nov 1988	Young swarms along the Senegal River; first to fifth instars in several regions.
19 - 25 Nov 1988	Fourth to fifth instars near Saint-Louis and Matam; larval bands with second to fifth instars at Kaolack and Zinguinchor.
26 Nov - 2 Dec 1988	Hopper bands with third to fourth instars at Casamance; immature swarms and hopper bands along the coast from The Gambia to near Saint-Louis and at Matam.
3 - 9 Dec 1988	Larval bands with third to fourth instars at Casamance; young locusts from Kaolack to Saint-Louis; larval bands with third to fifth instars at Thies.
10 - 16 Dec 1988	Immature swarms with a few mature individuals and hopper bands in the west from the Gambia to Saint-Louis.

This pattern of infestation clearly indicates that for 1988 initial infestation was in Mauritania, followed by Mali, then by Senegal. Though it is not clear from these data whether the infestation in Mali originated in Mauritania or was independent in origin, it seems very plausible to conclude that the infestation in Senegal had its origin in Mauritania or in Mali or both. The locusts arrived in Senegal as mature adults late in the season rather than arising from populations previously present in Senegal.

AGENCY FOR INTERNATIONAL DEVELOPMENT
BUREAU FOR AFRICA
Office of Analysis, Research and Technical Services/
Office of Operations and New Initiatives
AFR/ARTS-ONI

COUNTRY SPECIFIC SUPPLEMENTARY ENVIRONMENTAL ASSESSMENT (SEA) TO THE PROGRAMMATIC ENVIRONMENTAL ASSESSMENT (PEA) FOR LOCUST/GRASSHOPPER CONTROL IN AFRICA AND ASIA

FINAL ACTION FORM

COUNTRY: SENEGAL

DATE: May 1991

ACTION TAKEN:

Approved: ✓ Date 5/1/91

Disapproval: _____ Date _____

Bureau Environmental Officer: _____

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