Sahel Regional Aid Planning and Coordination Semiannual Management Report: 1 March 1980 - 31 August 1980

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Advisory Committee on the Sahel

Board on Science and Technology for International Development

Commission on International Relations

National Academy of Sciences - National Research Council

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ADVISORY COMMITTEE ON THE SAHEL

Members:

Staff:

INTRODUCTORY NOTE

As noted in our previous management report, the contractual statement of work for the Advisory Committee on the Sahel (ACOS) stresses cooperation with the Agency for International Development (USAID) directed toward increasing project impact in the areas of ecology, forestry, and adaptive technology, and assistance to the Sahel Institute (i) in organizing a unit for the coordination of environmental research and training, (ii) in establishing, in collaboration with the International Development Research Centre (IDRC), regional baseline data on research activities to be carried out in the Sahel, and (iii) in promoting scientific networking.

During the period treated in this report, ACOS activities have focussed upon agro-forestry, environmental rehabilitation, and networking. Although our efforts were geographically concentrated in the western Sahel, the observations and recommendations which emerged from them are of relevance to the region as a whole.

SUMMARY OF ACTIVITIES

An Analysis of Weather/Crop Yield Forecast Models in Relation to Drought in the Sahel

This study was undertaken as a joint effort by the ACOS and the

Academy's Climate Research Board in support of the activities of USAID's Office of Foreign Disaster Assistance. The ACOS contribution to the study was completed in March 1980, and the published results of the analysis are expected to appear in the near future.

An Assessment of Environmental Degradation and Agricultural Productivity in the Senegalese Groundnut Basin (14-21 April 1980)

An assessment of the groundnut basin was undertaken by an ACOS team of scientists at the request of the USAID Mission in Dakar and the Water and Forest Service of the Senegalese Government. The team was composed of the following individuals:

Peter H. Freeman, consulting geographer (BOSTID Consultant)

Abou Salam Kane, Environment Training Programme (ENDA)

Cyrus M. McKell (team leader), Institute for Land Rehabilitation, Utah State University

Filemon Torres, International Council for Research in Agroforestry (ICRAF)

A summary of the document describing the study is attached to this report as Appendix I. The document itself, "A Preliminary Assessment of Environmental Degradation and Agricultural Productivity in the Senegalese Groundnut Basin," is available upon request from the Advisory Committee on the Sahel.

Environmental Rehabilitation in Mauritania (22-30 April 1980)

In response to a request from USAID/Nouakchott, ACOS staff participated in an effort to further define Mission program activities in the area of environmental rehabilitation. This participation is summarized in a brief staff report to the Mission, "Notes and Comments Regarding Proposed USAID/Nouakchott Efforts in Reafforestation." The report is attached to this document as Appendix II.

ACOS Cooperation with the International Union for Conservation of Nature and Natural Resources (IUCN)

ACOS cooperation with the programs of the IUCN has continued through the current reporting period. A brief description of ACOS-IUCN discussions held 1-3 May 1980 at Gland, Switzerland is contained in the trip report attached as Appendix III. Further cooperation is assured through ACOS representation on the IUCN's Commission on Environmental Planning, the body responsible for the implementation of the World Conservation Strategy.

Training Film Based upon the Mauritania Environmental Workshop

The Training and Development Division of USAID recently completed a film based upon the September 1979 Mauritania Environmental Workshop,

a cooperative undertaking sponsored by the Mauritanian Ministry of Rural Development, USAID/Nouakchott, and the National Academy of Sciences. The workshop, which drew heavily from the April 1979 ACOS assessment of agro-forestry potential within the environmental framework of Mauritania, involved extensive travel through the various ecological regions of the country. The film accurately presents the promise and hazards of such itinerant ventures.

Sahel Regional Rhizobium Collection

Discussions regarding the creation of a regional Rhizobium collection have been continued with various officials in the Sahel, with Gilles Lessard of the International Development Research Centre in Ottawa, and with Deane Weber and Harold Keyser of the U.S. Department of Agriculture's Rhizobium Collection Center at Beltsville, Maryland. In anticipation of the establishment of a regional Rhizobium center, and in an effort to take advantage of the collection opportunities of the 1980 rainy season, collection phials were prepared by Dr. Keyser of the USDA and were distributed to researchers in the Sahel by the ACOS staff.

Scientific Networking

During September 1980, ACOS Director Michael Dow participated in a U.S. White House Science and Technology mission which concluded science

and technology agreements with the governments of Kenya, Nigeria, Senegal, and Zimbabwe. Dr. Dow took advantage of the occasion to discuss ACOS interests in Senegal and to establish or strengthen relationships with scientific bodies elsewhere, particularly in Kenya and Zimbabwe.

In Dakar, meetings were held with Jacques Diouf, Senegalese Minister of Science and Technology, with Louis Sauger, former Directer of the Senegalese Institute of Agricultural Research (ISRA), and with USAID Mission Director David Shear. The discussions with Dr. Shear dealt variously with follow-up activities related to the ACOS assessment of the Senegalese groundnut basin (see Appendix I), proposed ACOS assistance to USAID in connection with the development of the Senegal River Basin, and the proposed establishment of a regional Rhizobium collection in Senegal for the inoculation of leguminous trees and shrubs.

Additional discussions were held in Washington with Dr. Diouf, as well as with other Sahelian officials, including Abdoulaye Kane of the Senegalese Water and Forest Service and N'Gam Lirvane, Governor of Tiris-Zemmour (Mauritania). Further discussions with officials within the Sahel are recorded in Appendices I and III of this report.

Substantive discussions regarding the Sahel region were also held with officials or representatives of the following organizations during

the period covered in the report:

	Subject
Academy of Educational Development	Reafforestation, agro-forestry
AFRICARE	Spirulina and agro-forestry
American Association for the Advancement of Science (AAAS)	Halophytes and remote sensing
American Friends Service Committee (AFSC)	The AFSC's Tin Aicha (Mali) project
Appropriate Technology International (ATI)	Technology transfer
CARE	Reafforestation and agro-forestry
Catholic Relief Services	Village gardens and water management

Centre Regional Africain de Technologie (CRAT) (Dakar, Senegal)	Technology transfer
Club du Sahel Secretariat	Regional cooperation
Coordination in Development (CODEL)	Environmental rehabilitation
Desert Botanical Carden (Phoenix, Arizona)	Dryland trees, shrubs, and economic crops
Desert Research Project, Biosearch Trust (Cambridge, England)	Argania spinosa
Earth Satellite Corporation	Remote sensing potential in Sahel development
Environment Training Programme (ENDA)	Social-environmental relationships in the Senegalese groundnut basin
Family Health Care, Inc.	Health programs in Senegal
Food and Agriculture Organization of the United Nations (FAO)	Agro-forestry

German Forestry Mission to Senegal (GTZ)	Dryland economic plant species
Institute of Behavioral Science, University of Colorado	River-basin development
International Agricultural Development Service	Agro-forestry
International Council for Research in Agroforestry (ICRAF)	Agro-forestry
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	Short-cycle food crops
International Development Research Centre (IDRC)	Rhizobium collection, species selection
International Institute for Environment and Development	African wildlife
International Livestock Centre for Africa (ILCA)	Browse shrubs and pastoral systems

International Technology Development Group (London, England)	Technology transfer and diffusion
International Tree Crops Institute	Agro-forestry
International Union for Conservation of Nature and Natural Resources (IUCN)	World Conservation Strategy, crocodile management, desert wildlife management
Meals for Millions Foundation (Tucson, Arizona)	Dryland food crops
National Center for Atmospheric Research	Weather/crop yield forecast models
National Park Service	Wildlife management
National Science Foundation	Halophytes
Native Plants (Salt Lake City, Utah)	Halophytes, dryland economic crops

Organization for Rehabilitation Through Training (ORT)	Water buffalo
OXFAM	Micro-catchments and reafforestation
Peace Corps	Agro-forestry, reafforestation
Remote Sensing Institute, South Dakota State University	Environmental rehabilitation in Mauritania
Rockefeller Foundation	Technology transfer and diffusion
(Senegalese) National Center for Agricultural Research (CNRA)	Degradation, agro-forestry
(Senegalese) National Center for Forestry Research (CNRF)	Dryland trees and shrubs
(Senegalese) Society for Development and Agricultural Extension (SODEVA)	Extension activities in the groundnut basin
Smithsonian Institution	Dryland trees, shrubs, and economic crops

Solar Energy Research Institute (SERI)	Tree crops
Subsecretaria Forestal y de la Fauna (Coyoacan, Mexico)	Agro-forestry
The World Bank	Reafforestation and agro-forestry
The World Wildlife Fund (WWF)	Desert wildlife management
United Nations Development Programme (UNDP)	Environmental rehabilitation
United Nations Environment Programme (UNEP)	Desertification, environmental monitoring
United Nations Sudano-Sahelian Office (UNSO)	Environmental programs

FUTURE ACTIVITIES

Tentatively Scheduled Activities

Discussion Seminar on the Senegalese Groundnut Basin (Washington, D.C)	October 8, 1980
Staff consultation with ACOS Chairman (New Haven, Connecticut)	October 16, 1980
Meeting of the Advisory Committee on the Sahel (Washington, D.C.)	November 3, 1980
Discussions regarding botanical resources for Sahel development projects at the University of Arizona and the Desert Botanical Garden (Tucson and Phoenix, Arizona); Solar Energy Research Institute Workshop on Tree Crops for Energy Co-Production on Farms (Estes Park, Colorado)	November 7-14, 1980
Meeting of the Academy's Board on Science and Technology for International Development (New York City)	December 11-12, 1980

Working Discussions on the Establishment of a Regional Rhizobium Collection for the Sahel (Dakar, Senegal); Panel on the Ecology and Environmental Programs of the Sahel Institute (Bamako, Mali); and Program Follow-up (Nouakchott, Mauritania) — January 3-24, 1980

Proposed Activities

Panel on the Bioclimatic Evolution of the West African Holocene (Chicago, Illinois)

Critical Environments: Workshop on The Stabilization of Continental Dunes (Boutilimit, Mauritania)

Critical Environments: Workshop on the Reclamation and Utilization of Saline Environments (Fatik, Senegal)

An Overview of Selected Aspects of the OMVS Project Area in Relation to USAID/Dakar Program Development (Dakar, Senegal)

Workshop on Desert Wildlife Management and Utilization (Niamey, Niger)

Workshop on Crocodile Management (Ziguinchor, Senegal)

Working Discussions Concerning the Possible Contribution of the Water Buffalo to the Sahel (Banjul, The Gambia)

Working Discussions on the Further Development of Spirulina in the Sahel (Nguigmi, Niger)

Contents, Summary and Recommendations From

A PRELIMINARY ASSESSMENT OF ENVIRONMENTAL DEGRADATION AND AGRICULTURAL PRODUCTIVITY IN THE SENEGALESE GROUNDNUT BASIN

A report to the Advisory Committee on the Sahel of the

National Academy of Sciences

Dakar, Senegal

14-21 April 1980

National Academy of Sciences

Washington, D. C. 1980

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SUMMARY AND RECOMMENDATIONS

Summary

This report was prepared, at the request of the USAID Mission to Senegal and the Water and Forest Service of the Senegalese Government, by a group of experts selected by the staff of the NAS Advisory Committee on the Sahel to advise the Committee, USAID, and the Water and Forest Service regarding the terms of reference and content of a proposed program of collaboration to increase agricultural productivity and arrest environmental degradation in the groundnut basin of Senegal.

The report is based upon a brief study undertaken in the basin during the third week of April 1980. The observations and recommendations which emerged from the study were variously based upon the previous experience of the participants, the study of relevant documents, disscussions with Senegalese and foreign experts, village interviews, and some 1199 kilometres of travel within the basin.

The Senegalese groundnut basin is experiencing progressive environmental degradation, declining soil productivity, and limited economic options. The growing needs of the basin's increasing population are precariously dependent upon an agricultural system which has little remaining flexibility. Without adequate flexibility and diversity, it is doubtful that the system will be able to withstand the stress of the next severe drought and increasing human population pressure.

Because the basin is for the most part level, degradation tends to reveal itself in declining yields rather than in more obvious physical forms such as erosional features. However, because declining yields can also reflect erratic precipitation, soil characteristics, economic priorities, and cultural practices (including whether improved seed and fertilizers are used), it is difficult to separate these factors from environmental degradation per se. The effect of drought upon the vegetation is also difficult to distinguish from the impact of excessive exploitation. Hence, it is impossible, on the basis of our limited reconnaissance and discussions, to arrive at geographically defined strategies and measures for the rehabilitation of the groundnut basin.

However, the following broad recommendations support the Senegalese objective of sustained agricultural productivity in the groundnut basin, and would contribute to the formulation of location-specific economic alternatives.

Recommendations

1. The Senegalese Institute for Agricultural Research (ISRA), the Water and Forest Service, and the extension services should add new dimensions to the existing agriculture system by promoting:

   a. New crops, such as Calotropis procera (particularly as a source

of liquid hydrocarbon for fuel production), Cyamopsis tetragonoloba (guar), Psophocarpus tetragonolobus (winged bean), and Simmondsia chinensis (jojoba).

b. The propagation or reintroduction of useful native plant species which have become scarce or locally extinct, particularly fruit-bearing species such as Balanites aegyptiaca, Cordia gharaf, Deterium senegalense, Ficus platyphylla, F. vogelii, Margifera indica (naturalized), Parinari macrophylla, Parkia biglobosa, Tamarindus indica, and browse species such as Annona senegalensis and Ziziphus mauritiana.

c. Currently-produced crops with potential for new economic uses, particularly oil-producing plants, the oil of which can be used as fuel or lubricant for diesel engines. Examples include safflower, sunflower, palm, groundnut, cottonseed, coconut, sesame, and rapeseed oil.

d. More diverse food sources, particularly vegetable gardens to enhance village nutrition. Varieties with extended seasonal use and long storage life should be emphasized, and consideration should be given to the introduction of drought-tolerant vegetable crops such as Cucurbita mixta (Papago Cushaw squash), Phaseolus acutifolius (tepary bean), P. coccineus (Tarahumara runner bean), P. lunatus (Hopi mottled Lima bean), and P. vulgaris (Tarahumara pink bean). Drought-tolerant grain crops such as Amaranthus hypochondriacus (grain amaranth) and Zea mays (Pima-Papago sixty-day maize) might similarly be considered.

e. The selection of multipurpose trees and shrubs, both native and exotic, variously capable of providing browse, fruit, gum, construction materials, shade, fuel, and so on.

f. The use of tree plantation as land conservation measures as well as sources of fuel and construction materials.

g. The identification of browse species appropriate for use in living fences (Prosopis spp, Acacia spp., etc.)

2. The existing agricultural system should be expanded by adding a major emphasis upon animal production utilizing marginal lands. Benefits would include improved human nutrition from milk and meat, additional manure for cropped areas, and supplemental income from the sale of excess animals and animal products.

3. A comprehensive review of the resources and agricultural practices should be undertaken in order to determine their limits and implications for sustained production. The review could use as a point of departure existing data and could intially focus upon selected sample villages typical of the sub-regions within the groundnut basin. The preliminary results could be used to select priority environments for a more extensive survey leading to the design of rehabilitation measures.

4. Finally, it is suggested that additional information be gathered and interpreted to validate our recommendations and guide project design.

This could be done by a panel of the National Academy of Sciences or an Indefinite Quantity Contractor, or through the technical resources of USAID's Bureau for Development Support. Should it be evident that existing information is inadequate for design purposes, it is proposed that further preparatory work be done, as necessary, by Indefinite Quantity Contractors, through special arrangements with the National Academy of Sciences, or by universities.

NOTES AND COMMENTS REGARDING PROPOSED USAID/NOUAKCHOTT EFFORTS IN REAFFORESTATION

The Chemama

--Although compensation for the loss of gonakier (Acacia scorpioides var. nilotica) stands through charcoal production and OMVS program activities is of critical importance, it may be unrealistic to initially approach the problem through direct replacement. While the 1977 SOGREAH overview of the Diama Reservoir at 2.50 m. retention generally describes the projected extent of periodic inundation, there is only partial agreement among the overview, statements in the Gannett-Fleming reports, and other sources of information regarding the extent of the area to be impacted. GIRM comments regarding OMVS commitments to replace the lost trees are also ambiguous. Hence, it is suggested that attention initially be focussed upon the establishment of an irrigated urban plantation to provide charcoal and poles for Nouakchott. It is further suggested that the plantation be located between Rosso and Keur Massene. The rationale for the proposed plantation would include the following elements: (i) Such an effort could be organized with little delay by the GIRM and interested donors. (ii) It will be much less difficult to accurately assess the real forestry needs of the Chemama once the pressure of Nouakchott is removed from the "natural" system, the OMVS impact is better understood, natural regeneration is reassessed, and there is some movement toward a new equilibrium. (iii) The establishment of the plantation west of Rosso would variously guarantee labor availability, facilitate irrigation, permit direct access to Nouakchott over all-weather road, and allow the plantation to serve as auxiliary habitat for the Keur Massene reserve and the neighboring Djoudj National Park in Senegal.

With reference to species composition, it might be well to initially concentrate upon species with known performance such as Eucalyptus camaldulensis and Salvador-type Leucaena leucocephala: both are widely used elsewhere for poles and charcoal (the heating value of the less well known leucaena charcoal is around 7000 to 7250 calories per kilogram). In addition to its rapid growth, leucaena is of value as a companion species because its roots house Rhizobium bacteria which fix atmospheric nitrogen. This would be of apparent value in accelerating the growth of the eucalypt (there is some disagreement regarding the mechanisms) and partially compensating for its depletion of nutrients. The forage value of leucaena would further permit the plantation to serve as a browse reserve for domesticated livestock and wild ungulates following a period of initial protection sufficient for the establishment of the trees. It is further recommended that concomitant research be undertaken at the plantation to evaluate other species perhaps better adapted to the local conditions of the project area.

The extent of the plantation would variously depend upon species composition, site conditions, management systems, and demand (for which it would be necessary to determine the Nouakchott proportion of current demand, taken at 1,100,400 tons of wood per year for the country as a whole, and project the rate of demand increase to compensate for the five- to six-year interval of the initial cutting cycle). For purposes of economic justification, it will be important to add the value of poles to that of charcoal (currently around 6000 ouguiyas per ton). Benefits such

as the creation of new employment opportunities and environmental amelioration might also be cited. If nothing else, the Nouakchott Greenbelt Project nicely demonstrated that the secondary effects of such projects, such as microclimatic modification, can stimulate the regeneration of native species in adjacent areas and generally contribute to the rehabilitation of the local environment.

--A second high priority activity might be the restoration of selected classified and protected forests. Species selection should be guided by existing forestry records and the observations of local populations, and should consider lower-story (grasses and shrubs) vegetation as well as trees. The degree of classification or level of protection should be sufficiently restrictive that the forests could serve as living herbaria or reservoirs of genetic diversity as per the biosphere reserve program which emerged from MAB Project 8. It should perhaps be repeated that our interest is in restoration rather than in "upgrading" or "enrichment." Hence, exotic species such as the neem (Azadirachta indica) should not be considered in connection with this particular effort. Information regarding the former composition of these remanent forests could be obtained from Diack Taleb or Banda Eyih of the Mauritanian Direction Protection Nature. Should the forest of Silbe be selected for restoration, as discussed during my recent visit to Nouakchott, reference should be made to Decree No. 10.028 of 17 February 1961 in order to determine how the altered status of the forest might affect program objectives. Unlike the suggested urban plantation project, initial efforts could, and perhaps should, be limited to more stringently enforced protection. A scheduled active phase could follow as soon as resources and interest permit.

--It is suggested that a supervised program be established which would result in the direct replacement of trees felled above the 2.50 m. retention level of the Diama Reservoir in connection with charcoal production. Minimally, the program would contain the following components: (i) The establishment of a nursery at Rosso for the provision of seedlings. (ii) Responsibility for the planting and protection of the replacement seedlings would reside explicitly with the permit holders who profit from the production of charcoal. The method of protection could be as simple and inexpensive as the single-tree exclosures used locally in village plantings or the erection of thorn fences utilizing the smaller branches of the trees felled. (iii) Enforcement could be regulated under the terms of Decree No. 65.080 of 29 April 1965, which fixes the fees for the exploitation of forest products. In this case, payment in kind could be viewed as being more appropriate than cash payment given the obvious limitations of the resource exploited and given the documented irregularities of the present system.

--Many formerly forested areas along the Senegal River between Boghe and Rosso have been totally denuded of trees and shrubs. Such an area is illustrated in Figure 1 of our April 1979 report, "An Assessment of Agro-Forestry Potential within the Environmental Framework of Mauritania." In the year since the assessment was made, erosional activity, particularly gullying, has increased measurably. The rate of increase and its far-reaching implications add a note of urgency to the following recommendation:

Initially keying upon areas most damaged by erosion, it is suggested that barbed-wire exclosures be established, protecting parcels of perhaps one hundred hectares. The effort should first address erosion control. If land preparation, either manual or mechanical, is envisioned for the project, many of the necessary control measures could be undertaken in the course of such preparation (filling, the establishment of diguettes or microcatchments to interrupt surface flow, &c.). Many variations of the fenced reafforestation parcels might be considered depending upon the range of needs to be served. These might include: the provision of

forest products; use as browse reserves; control of access to areas susceptible to erosion; training and experimentation in methods of revegetation; the study of natural regeneration; dune stabilization or interception; the reestablishment and maintenance of wildlife populations; &c. The range of needs combined with site characteristics would naturally influence design, surface treatment, species selection, and other considerations. Certainly to the extent possible, these projects should conform to the FLCD approach, needs should largely be defined by local populations, and it should be made clear that these populations are to be the direct beneficiaries of the projects.

It is suggested that a broad range of native and exotic species be considered for these projects. Although it might be worthwhile to consider Acacia scorpioides var. adstringens among the natives, it is doubtful that A. scorpioides var. nilotica, the gonakier previously dominant in the area, could successfully be reestablished. Research conducted in Sudan in the 1950s indicated that the latter is sustained by the exceptional floods responsible also for the dispersal of its seed. This dependency is reflected in the age classes of existing gonakier stands. Such floods will, of course, be eliminated with the completion of the Manantali Dam. As many of the species envisioned can be established by direct seeding, the projects could be initiated without nursery support.

The Chemama, The Dry-farmed Agricultural Zone, and Agricultural Oases

--Although not properly falling within the purview of reafforestation, agro-forestry can contribute in a substantial way to environmental rehabilitation. The agro-forestry approach is integrative and highly flexible. Elements of the approach which would relate directly to reafforestation concerns would include the following:

(i) The establishment of field trees such as Acacia albida. A. albida is particularly valuable because it comes into leaf following the rainy season and remains green during the hot, dry season. Hence, it does not deny sunlight to crops during the most critical period of their growth, it provides nitrogen enrichment, and provides livestock with shade (which reduces water need) and forage following the harvest. The manure which accumulates around the trees during the dry season further enriches the field for the next cropping cycle. It might be added that the crisis mentality of the 1970s has resulted in an unwarranted conservatism in relation to forestry projects in the Sahel. While Goor and Barney, Weber and other sources may bracket A. albida or A. senegal between the 300 and 500 mm. isohyets, it does not mean that either requires a minimum of 300 mm. in any given year. A. senegal, for example, has been known to survive 50 mm. years with little apparent damage. To perhaps belabor the obvious, the trees and shrubs of the region are adapted to the precipitation variability of the region.

(ii) Many useful tree species serve well as living fences. For example, Prosopis juliflora fences produce palatable leaves, pods which are eaten by livestock or can be ground into flour for human consumption, flowers which produce nectar of good quality for honey, and fuel. (As they sometimes harbor nematodes, care should be taken in their placement.) Acacia senegal, with its broad range of products (gum arabic, tannin, browse, fuel), can also be used in living fences.

(iii) Marginal lands near villages, including lands subject to erosion, could be planted in forage trees and shrubs. In addition to stabilizing the areas, such areas could serve as browse reserves, sources of fuel and, depending upon the

species planted, sources of gum and other forest products capable of generating supplemental income.

The Dry-farmed Agricultural Zone, The Pastoral Zone, and Agricultural Oases

--For obvious reasons, Sahelian villages and deep wells are foci of environmental degradation in rural areas. Many assistance programs have responded to the problem by promoting the establishment of village woodlots. Unfortunately, fuel scarcity is only a part of the problem, often a surprisingly small part in terms of local perception, and woodlots designed principally to serve fuel-wood needs have proven susceptible to the usual difficulties encountered in managing the commons. While family plantations may avoid some of the more overt difficulties, the continuing emphasis upon the provision of fuel wood itself obscures the complexity of the problem and could conceivably prolong its resolution.

Shelterbelts, fodder reserves, gum-arabic plantations, orchards, and the like are often conceptually separated from woodlots. I believe that this is unnecessary, and suggest the following: It is proposed that extensive (perhaps one- to three-hundred hectares), fenced "shelterbelts" be established to the north-east of villages and well points experiencing serious degradation. The shelterbelts would be designed to protect villages, fields, and wells from the effective dry season north-easterlies. By performing this function, they would also intercept drift sand, allow dry season seed scatter over the areas of most intense abuse, and otherwise ameliorate the local environment (intercept precipitation and promote infiltration, lower soil temperatures, recycle nutrients, permit the reestablishment of soil microorganisms, support wildlife, &c.). Through thoughtful species selection, the shelterbelts could also provide fodder, a variety of economic products (such as gum arabic, tannin, fruit, honey, and poles) and medicinal substances as well as fuel wood. By increasing the uses and economic value of the shelterbelt, it becomes less subject to neglect and predation. This has been well demonstrated in the case of the northern Senegalese village, Vidau Thingoly. In this case, the villagers have free access to a recently established, fenced forest reserve (not positioned to serve also as a shelterbelt), but livestock are excluded. At the time of our April visit to Vidau Thingoly, the villagers were particularly pleased with the ready availability of fodder, which they would cut and deliver to their livestock. The villagers or pastoralists directly affected by the projects should participate in the design of the projects, particularly in species selection, and it should be made clear immediately that they are to be the beneficiaries of their efforts. It would be most useful if arrangements could be made for the elders of Vidau Thingoly, Mbiddi, or other villages with fenced forest reserves to discuss the pros and cons of the reserves with the elders of Mauritanian villages during the design phase.

In establishing shelterbelts, it is important not to neglect lower story species, as the turbulence of lower free-flowing layers of wind is often increased by belts composed only of taller trees and damage can actually be increased by their exclusive use. Special note should also be made of the potential of gathering and feeding the pods of large-seeded legumes, such as Acacia spp. and Prosopis spp., to livestock. The livestock, which do not digest the seeds themselves, transport and deposit the seeds, thus acting as agents of dispersal and contributing further to regional revegetation. It might be noted further that wild ungulates were formerly responsible for the widespread distributions of many African acacias and,

to cite a more controversial example, the movement of range cattle was largely responsible for the dispersal of mesquite in the American South-west.

Pastoral Zone

--From the fifteenth through the nineteenth centuries, European interest in Mauritania focussed largely upon trade in gum arabic, the exudation of the Acacia senegal. This focus is reflected in the early maps of West Africa containing commercial information and is documented in the colorful history of Arguin Island, an important trading center in gum arabic variously held by the Portuguese, Dutch, British, and French--the contest ending with the British withdrawal in 1857 against French cession of Albreda on the Gambia. Given our interest in the restoration of A. senegal stands, it is of definite interest that for almost four centuries the commercial exploitation of gum arabic in Mauritania was centered in the western part of the country between latitudes 18° and 21° N. It is of further interest that gum production in that region withstood a series of severe droughts in the 1680s, c. 1738-1756, the 1770s, the 1790s, and the 1830s--the last evidently being more severe than those of the present century. Nevertheless, perhaps owing to an expansion of pastoral activity following the French pacification of the region, the "gum forests" have disappeared during the twentieth century.

It would appear to be the devegetation of this region in combination with the disturbances related to mining activity north-east of Nouakchott which are chiefly responsible for the increasingly severe dust-storms of the Nouakchott region. Given the effective dry season north-easterlies, this would be expected simply on the basis of map relationships among F'Derick, Akjoujt, the former "forests," and Nouakchott. Further verification was obtained through direct observation in the course of a flight taken from Kaedi to Nouadhibou during the much discussed dust-storms of April 1979. Although visibility was good at Kaedi and at Nouadhibou, it was only fifty metres in Nouakchott. From our aircraft, the dust-storm, which had practically immobilized Nouakchott, had a confined, linear aspect indicating point sources to the north-east of the city.

Acceptance of the former existence of "gum forests" to the north and north-east of Nouakchott, the importance of such stands in promoting surface stability, and the fact that some A. senegal regeneration was observed within the region in September 1979, suggest that some attention might be directed toward the region in connection with the proposed USAID program in reafforestation.

--While the precise reasons for the destruction of the more northerly stands of A. senegal are not known, the circumstances leading to the destruction of the more southerly stands of Trarza and Brakna are relatively easy to identify: (i) A. senegal is a short-lived tree (about twenty-five to thirty years) which occurs in age graded stands. Most of the dead trees examined in April and September 1979 were old, and regeneration was hindered by foraging livestock. (ii) The gum produced by the tree is apparently a stress substance, and the trees were tapped excessively in order to maximize short-term profits (possibly to compensate for the declining profitability of livestock). What we have seen in Trarza and Brakna is the predictable impact of a severe drought upon old, mutilated trees: The trees died.

As Technical Director of the Chadian gum-arabic monopoly in the mid-1970s, I was struck by the willingness of pastoralists to initiate efforts leading to the reestablishment of A. senegal stands. The initiatives reflected the high value attached to the tree and its products. The tree can be used in living fences; provides browse and supports honey production; is a source of tannin, wood, and charcoal; its hard wood is often used in the manufacture of tool handles, weavers' shuttles and the like; and a strong fibre can be obtained from the long, flexible surface roots. Traditionally, the gum enjoys a range of uses extending from the preparation of the ink for the tablets of Qur'anic schools to use, in solution, in stabilizing the interior walls of mud-brick structures. Exported gum is used in the manufacture of medicine, chewing gum, confectionery, soft drinks, and a variety of foods. It is also used in the textile industry.

The presence of large numbers of fallen A. senegal trees in Trarza and Brakna introduces an excellent opportunity to enlist the assistance of pastoralists and local villagers in a program of extensive revegetation. Untreated seed could be planted by dibble directly under the protective debris of the fallen trees. The seedlings emerging through the branches of these trees (i) would be protected from livestock--as attested by the relative abundance of grass under the fallen trees, (ii) could utilize the vacated root channels of the dead trees, permitting rapid tap root penetration and thereby better assure the seedling's chances for survival during the dry season, (iii) would profit from the nitrogen released by the decay of the dead acacias, and, finally, (iv) by planting directly under the fallen trees, chances are good that the Rhizobium strains normally associated with the A. senegal (and which are responsible for nitrogen fixation) would already be in place.

The reintroduction of A. senegal in Trarza and Brakna should be accompanied by a program of instruction in less destructive tapping methods (which could be designed, and perhaps implemented, by A. G. Seif el-Din, a gum-arabic specialist employed by the International Development Research Centre) and by the development or reactivation of a dependable marketing system for gum arabic. To a great extent, the well-being of the trees depends upon the ability of the collector to market his gum. If the gum cannot be conveniently marketed, interest in the trees will shift from gum production to browse, fuel, and other uses which are intrinsically damaging to the trees. Should questions arise regarding the status of gum arabic on the world market, they should be directed to: Professor D. M. W. Anderson, Department of Chemistry, University of Edinburgh, West Mains Road, Edinburgh, EH9 3JJ, United Kingdom.

Charles Toupet has associated the destruction of A. senegal stands around Boutilimit with the reactivation of dunes in that area. Failure to reestablish the A. senegal stands of Trarza and Brakna might well lead to the reactivation of stable dunes, an eventuality which would greatly complicate dune stabilization programs in those regions. An appreciation of the stabilizing potential of A. senegal can be gained from the illustration of the tree's root system which appears in the NAS volume, Tropical Legumes: Resources for the Future, p. 282.

Coastal Zone, Pastoral Zone and Agricultural Oases

--Dune stabilization efforts might be divided into two components: (i) the reinforcement of currently immobile dunes subject to destabilization through the removal

of vegetative cover and physical disturbance (largely coincident with the former distribution of Acacia senegal and perhaps best addressed through the reestablishment of A. senegal and associated species) and (ii) the stabilization of mobile dunes. As a matter of convenience, programs dealing with the stabilization of active dunes might be separated into coastal and continental components, the first drawing heavily from experience already gained in neighboring Senegal (research contact: Eaux et Forets Director El-Hadji Sene, B.P. 1831, Dakar) and in coastal deserts elsewhere, the latter with more apparent affinities with efforts in such interior deserts as those of contiguous North Africa and the Indian subcontinent (for example, the work of Janos Toth in Algeria and R. N. Kaul in Rajasthan--their addresses can be found in the attached proposal to establish agro-sylvo-pastoral centers in Mauritania).

Within the coastal zone, initial attention might be directed toward the Nouakchott area proper and the areas of encroachment along the Nouakchott-Rosso highway. Despite its apparent shortcomings, the Nouakchott Greenbelt has already had a stabilizing impact upon the Nouakchott region, both through the physical presence of the Prosopis chilensis seedlings and the microclimatic modifications which have permitted some regeneration of local species (it would be worthwhile to repeat the September 1979 visit in September 1980 in order to determine establishment percentages). Obviously, however, even a successful Greenbelt would not solve the city's problems of encroachment (many of which are internally generated by construction activities and circulation) and a systematic program of sand removal and stabilization might be recommended for Nouakchott. Such a program could draw upon the diverse resources of the city (manpower, equipment, &c.), would be highly visible (which, following discussions with various Mauritanian officials, I would judge to be of some importance to the USAID Mission at the moment) and, given the resources of the city, could have a more active research component. It is important not to undertake experimental programs in areas with limited resources, as it is often extremely difficult to resurrect such programs should failure occur.

Efforts along the Nouakchott-Rosso highway would profit from many of the considerations noted for Nouakchott. The importance of the effort is tragically underscored by the many highway accidents caused by drifting sand each week.

With regard to species selection, attention should initially be directed toward the local species of the coastal desert, particularly toward Euphorbia balsamifera and Tamarix senegalensis. These species are easily established, can be irrigated, if necessary, with brackish water, and should be considered for the mechanically stabilizing checkerboard fences. Athel tamarisk or Acacia senegal could be planted within the checkerboards, depending upon site conditions. Both species are of economic value, although the value of A. senegal exceeds that of the tamarisk. On the other hand, the low palatability of the tamarisk affords some protection from foraging livestock. Other species which might be considered would be Acacia raddiana, A. cyanophylla, A. cyclops, Parkinsonia aculeata, Salvadora persica, and Vernonia spp.

For interior dunes and for stabilization along the Nouakchott-Nema highway, mechanical stabilization might be attempted with Euphorbia balsamifera, Agave spp., or palm fronds. Plantings within the checkerboards for further stability and the contribution of organic matter might include species such as Acacia senegal, A. raddiana, Cercidium floridum, and Prosopis juliflora. Each has been successfully planted in analogous situations elsewhere. In order to further promote economic diversity in rural areas, it might be worthwhile to determine if economic species such as jojoba (Simmondsia chinensis) could contribute to programs of dune stabilizat

While it should not be difficult to locate technicians, such as Ba Mohamed at Kaedi, to carry out a program of stabilization in the interior, it is extremely important that the design team include senior individuals, such as R. N. Kaul, with demonstrated success in dune stabilization under similar conditions.

With regard to the selection of sites for dune stabilization efforts in the interior, some thought might be given to the historical, social, and religious importance of particular oases. Although such considerations might seem to be excessively aesthetic in nature, they have some rather practical dimensions. For example, the growing influence (my impression) of the Mauritanian marabouts might contribute further justification to the targeting of religious centers such as Chinguetti, Boutilimit, Mederdra, and Oualata for efforts in dune stabilization.

MISCELLANEOUS

Project diversity and flexibility

--The diversity of the above suggestions and comments reflects the belief that programs in environmental rehabilitation (including reafforestation) should be better related to the dynamics of environmental systems: effective winds, animal movement, the phenology of the principal species involved, &c. This implies further that greater importance be attached to the nature, scale, and geographical distribution of project components. By more carefully relating project components to the dynamics of natural (and, in some instances, social) systems and processes, the dynamics can be exploited to amplify the impact of the project.

It is suggested that some flexibility be written in to the project in order to accomodate unanticipated activities and changing priorities. For example, it might later be found desirable to expand the project to include efforts such as: (i) Habitat renewal for wildlife in the borderlands of the Majabat al-Koubra in an arcuate zone extending southward from Atar into the Tagant, and eastward through Tichit to Bou Dib. The ecological and economic justification, as well as a suggested methodology, is contained in the summary report of the September 1979 Mauritania Environmental Workshop. (ii) Trial plantings of Prosopis tamarugo, Atriplex spp., and other salt-tolerant species in the Aftout as-Saheli. Comments regarding tamarugo can be found in the NAS volume, Underexploited Tropical Plants with Promising Economic Value, pp. 128-131. (iii) Land reclamation or stabilization in connection with mining activities.

Project coordination

--Obviously, a project containing components as diverse as the establishment of urban plantations, the restoration of classified forests, revegetation by charcoal producers, reafforestation along the Senegal to increase the availability of forest products and reduce erosion (both the rates and implications of the deposition of sediment within the OMVS area have seemingly been underestimated), various agro-forestry efforts, the establishment of shelterbelts, the reestablishment of Acacia senegal stands, and efforts in dune stabilization would require a somewhat

unconventional approach to coordination. It is suggested that the various project activities be coordinated through centers such as that described in our February 1980 "Proposal to Establish Two Agro-silvo-pastoral Centers in Mauritania." A copy of the draft proposal is attached. The creation of these or similar centers has been discussed with Roger Conrad of the Peace Corps/Mauritania staff, and it appears that there would be some possibility of Peace Corps participation in the staffing of the centers.

Aerial seeding

--In the course of our April 1979 discussions in Mauritania, it was repeatedly stressed that the country required a massive effort in reafforestation. For example, it was estimated that at least 20,000 hectares of gonakier forest would be lost in connection with OMVS activities alone. In our report on these discussions, "An Assessment of Agro-forestry Potential within the Environmental Framework of Mauritania," an attempt was made to place this problem in perspective:

> ". . . the revegetation of 20,000 hectares would be a massive operation. At 1000 trees per hectare, 20 million seedlings would be required. The Nouakchott greenbelt operation has been able to plant only 385 hectares in three years, admittedly under difficult conditions, but with the diverse resources of the national capital at hand, with funding amounting to $3.50 per tree to date, and with a work force of 210 individuals. With present resources and the application of traditional forest management methods, it is estimated that it might take more than 100 years to reforest an area equivalent to that which is threatened."

It was in this connection that aerial seeding was suggested as one element of an experimental "shotgun" approach to reafforestation in Mauritania.

It has become evident in the course of recent discussions that, by many, aerial seeding is regarded as being somewhat more experimental than it actually is. This might reflect the fact that most efforts in aerial seeding are rather anonymously undertaken by governmental agencies or private corporations to address specific problems, such as the revegetation of extensive or inaccessible tracts, which cannot be adequately addressed by more conventional approaches. Both because of the parochial nature of such efforts and because their environmental context is assumed to be vastly dissimilar to conditions in tropical Africa, they have been largely neglected or dismissed by individuals dealing with revegetation in the Sahel. It should therefore be noted that successful efforts in aerial seeding have been undertaken in areas of the developing world quite similar to the Sahel in terms of precipitation totals and distributions. For example, a 1959-1960 Nigerian Forestry Department Report describes their experience in sowing neem (Azadirachta indica) from the air in the Northern Region. M. N. Vaishnav, Conservator of Forests in Gujarat, notes that aerial seeding of Prosopis juliflora was successfully employed in dune stabilization efforts in India in the 1950s. Similarly, the Sudanese Forests Department has for years broadcast the untreated seed of Acacia nilotica (=Acacia scorpioides var. nilotica) to restore sunt (=gonakier) forests along the Blue Nile.

With specific reference to Mauritania, reservations regarding aerial seeding have largely related to (i) anticipated problems of seed availability, (ii) the adequacy of precipitation, and (iii) predator pressure.

--Aerial seeding operations characteristically require large quantities of seed. While such quantities are often available through international organizations, governmental agencies, and/or commercial firms, the question of adaptability favors local sources to the extent possible. Some seed, for example that of Acacia senegal, is available in local markets in Mauritania. Larger quantities could be obtained through the organization of a seed-collection program in rural areas. Such a program was successfully undertaken for the procurement of Acacia senegal seed in Chad in 1975. The Chadian campaign yielded substantial quantities --sufficient for all projected plantation development activities, the establishment of village gum gardens, and for direct seeding efforts undertaken by pastoralists in Batha and Ouaddai. I proposed such a campaign for Mauritania to Cheikh Lamine O. Hamma of the Direction Protection Nature in a letter dated 14 February 1980. There has been no response. (In the specific case of Acacia senegal, local collection should be complemented by seed obtained from the Senegalese gum arabic station at Mbiddi.)

--As an Arizonan having lived most of my life in areas receiving less than 200 mm. of precipitation per annum, I am perhaps less inclined than others to automatically refer the problems of the Sahel to climatic causes. Given the reputedly intractable nature of Mauritania's problems, it might be worth noting that Kiffa shares its precipitation average (350 mm.), summer distribution, and approximate drought frequency with such non-Sahelian communities as Fort Stockton, Texas; Roswell, New Mexico; Denver, Colorado; Williston, North Dakota; and Helena, Montana. Obviously, the comparison is incomplete. The point, however, is that we are dealing with levels of precipitation which are somewhat higher than those often assumed; levels which permit us to more directly relate the proposed trials in Mauritania with successful efforts in the United States, Australia, Canada, and elsewhere.

Mauritania, with a relatively brief rainy season and extended dry season, enjoys certain advantages over areas with the same precipitation totals but with longer rainy seasons (as is the case with all of the U.S. communities noted above). Most of the plant species which would be considered for aerial seeding in the Sahel have rapidly developing tap roots. For such species, the most effective rainfall distribution is when large amounts fall within a short period, preferably at a time of low evapotranspiration. Such rainfall replenishes the deeper moisture reserves on which such species are dependent for their permanent water supply. Because of the extended dry season, there would also be less ground cover and the seed would have a better chance of falling directly onto mineral soil.

--With regard to predator pressure, rodents, insects, and birds are regarded as being the principal threats. The extended dry season dramatically reduces their numbers. Rodent populations in rural areas were relatively modest during our April visit. The general lack of vegetation also resulted in modest insect populations and a correspondingly limited number of insectivorous birds. The following insectivorous species were recorded in the course of our April travels in an effort to indirectly check potential insect pressure:

Swifts (Apodidae)
Cattle Egrets (Bubulcus ibis)
Ground Hornbill (Bucowers abyssinicus)
Senegal Coucal (Centropus senegalensis)
Pied Kingfisher (Ceryle rudis)
Abyssinian Roller (Coracias abyssinica)
Swallows (Hirundinidae)

Brown-backed Woodpecker (Ipophilus obsoletus obsoletus)
Helmet Guinea-Fowl (Numida meleagris)
Grey Hornbill (Tockus nasutus)
Purple Glossy Starling (Turdus purpureus)
Senegal Hoopoe (Upupa senegalensis)
Spur-winged Plover (Vanellus spinosus)

Most of the insectivorous birds were seen along the river. None appeared in large numbers, although several villages supported substantial starling populations.

With regard to direct predation, the following granivorous bird species were recorded:

Pied Crow (Corvus albus)--omnivorous
Red-cheeked Cordon-Bleu (Estrilda troglodytes)
Crested Lark (Galerida cristata)--also feeds on insects
Senegal Fire-Finch (Lagonosticta senegala)
Bush-Sparrow (Petronia dentata)
Senegal Long-Tailed Parrakeet (Psittacula krameri)
Chestnut-bellied Sand-Grouse (Pterocles exustus)
European Turtle-Dove (Streptopelia turtur)
Vinaceous Dove (S. vinacea)
Mourning Dove (S. decipiens)
Bruce's Green Pigeon (Treron waalia)

Again, none appeared in large numbers and, collectively, the granivorous species would not pose a threat to seeding early in the rainy season. Most granivorous species migrate into southern Mauritania in late July or August as seed becomes available. The above observations, made 25-27 April, are in general agreement with the findings in the Gannett-Fleming report on ornithology.

--Finally, it should be stressed that we are proposing aerial seeding as an experimental approach to extensive revegetation. It is viewed as being complementary to more traditional approaches, not as a replacement for them. The experiment may fail. Should it succeed, however, the implications for the Sahel and for similarly degraded areas obviously would be tremendous.

NATIONAL ACADEMY OF SCIENCES
NATIONAL RESEARCH COUNCIL
2101 Constitution Avenue Washington, D.C. 20418 USA

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BOARD ON SCIENCE AND TECHNOLOGY FOR INTERNATIONAL DEVELOPMENT

TRIP REPORT

TRAVEL TO: Senegal, Mauritania, Switzerland, and France;
21 April - 5 May 1980

BY: Jeffrey Allman Gritzner, Professional Associate, BOSTID

FUNDING: Contract AID/afr-C-1354

ITINERARY AND MEETINGS

April		
21	Dakar, Senegal	Melvin McCaw, Deputy Mission Director, USAID/Dakar Samuel Rae, USAID/Dakar Erv Berglund, forester, University of Minnesota (USAID/Rabat) Carol Stoney, USAID/Dakar Mamadou Jallow, USAID/Dakar Claude Charreau, West Africa Project Leader, ICRISAT John Schauring, ICRISAT/Mali Jean Gorse, The World Bank
22	Dakar	Melvin McCaw Samuel Rae Erv Berglund Mamadou Jallow Lucie Colvin, University of Maryland (Baltimore County) Joseph Salvo, USAID/Dakar Paul Wenger, USAID/Dakar Jerry Stern, Director, Peace Corps/ Mauritania
	Nouakchott	
23	Nouakchott	J. Rowland Illick, geographer, USAID/ Nouakchott James Hughes, agronomist, USAID/Nouakchott Allen Reed, USAID/Nouakchott Demba Samoussa, Mauritanian Service for the Protection of Nature John Heermans, forestry consultant to USAID/Nauakchott Roger Conrad, Associate Director for Agriculture and Rural Development, Peace Corps/Mauritania Andy Linehan, Peace Corps Volunteer, Keur Massène

24	Nouakchott	John Heermans Thaleb Diack, Mauritanian Service for the Protection of Nature Demba Samoussa John Hoskins, Mission Director, USAID/ Nouakchott J. Rowland Illick
25	Nouakchott	James Dickey, Sahel Development Planning Regional Office, USAID Roger Conrad John Heermans Demba Samoussa
	Hassei el Gourdane Rosso Ross-Béthio, Senegal Saint-Louis Rao Mpal Louga Nguermalal Keur Momar Sarr	Lieutenant-Governor Moulaye
26	Bowdé Doudal (Mbar Toubab)	Discussion with assembled villagers
	Vidau Thingoly Galena	Discussion with assembled villagers
	Mbiddi	Etienne Manga, Senegalese Water and Forest Service
	Dagana Richard-Toll Rosso, Mauritania	Abou Diop, Mauritanian Service for the Protection of Nature
	Jader el Mohguene	
27	Tékane Jader el Mohguene Rosso Hassei el Gourdane Nouakchott	Discussion with assembled villagers
28-30	Nouakchott	John Hoskins James Dickey Mona Fikry, anthropologist, USAID/ Nouakchott John Grayzel, anthropologist, USAID/ Nouakchott James Hughes J. Rowland Illick Allen Reed Sally Sharp, USAID/Nouakchott

		John Heermans Roger Conrad Thaleb Diack Fadel Touré
	Dakar, Senegal	
May		
1	Dakar Yof Geneva, Switzerland Versoix Coppet Céligny Nyon Gland	Erv Berglund Robert Winterbottom, Ecology Team, CILSS Pierre Hunkeler, Executive Officer, Commission on Environmental Planning, IUCN
2	Gland	Pierre Hunkeler John Kundaeli, Program Officer for Africa, IUCN Harold Eidsvik, Executive Officer, Commission on National Parks and Protected Areas, IUCN
3	Gland Nyon Céligny Coppet Versoix Geneva Paris, France	
4	Paris	Jean Gorse Laurent de Nazelle
5	Paris Washington	Arthur Fell

DESCRIPTION AND COMMENTARY

This report deals with travel subsequent to an Advisory Committee on the Sahel (ACOS) study undertaken in Senegal during the third week of April, 1980. The study, requested by the United States Agency for International Development (USAID) and the Senegalese Water and Forest Service, is described in a separate report tentatively entitled "A Preliminary Assessment of Environmental Degradation and Agricultural Productivity in the Senegalese Groundnut Basin."

Upon the conclusion of the groundnut-basin study, several additional meetings were held at the USAID Mission in Dakar: Meetings with Carol Stoney and visiting forester Erv Berglund variously dealt with the selection of trees and shrubs appropriate for efforts in agro-forestry and environmental rehabilitation in the Sahel. Of the species discussed, Miss Stoney was particularly interested in the possible contribution of Terminalia catappa (tropical almond), a tree capable of providing edible fruit, oil, tannin, dye, gum, wood, and foliage favored by the Tasar silkworm. Trial plantings of T. catappa have apparently been undertaken in the Saint-Louis region of Senegal. Discussions with Deputy Mission Director Melvin McCaw dealt largely with the extent to which development efforts seemingly continued to emerge from unexamined Western concepts and perceptions rather than from the disinterested analysis of existing systems and processes; those with Joseph Salvo dealt broadly with agricultural innovation and community development; those with Paul Wenger

focussed upon possible Academy contributions to the Mission's efforts in the Senegal River basin. Meetings were also held with Lucie Colvin, Mamadou Jallow, and Samuel Rae.

Before leaving Dakar, further discussions were held with Claude Charreau of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT); with John Scheuring, an ICRISAT agr. conducting research in Mali; and with Jean Gorse of The World Bank, who was leading a Bank assessment of the Sine-Saloum region. While in Mali earlier this year, we discussed with Dr. Scheuring the possibility of undertaking trial plantings of various New World short-cycle food crops in the Sahel. Particular attention was directed toward crops such as Amaranthus hypochondriacus (grain amaranth), Cucurbita mixta (Papago Cushaw squash), Phaseolus acutifolius (tepary bean), P. coccineus (Tarahumara runner bean), P. lunatus (Hopi mottled Lima bean), P. vulgaris (Tarahumara pink bean), and Zea mays (Pima-Papago sixty-day maize). We hope that trials can be initiated for the above crops during the 1980 rainy season, and have requested seed accordingly.

During a Washington visit, USAID/Nouakchott Mission Director, John Hoskins, requested ACOS assistance in formulating a reafforestation project for the Mission. Hence, staff travel to Mauritania was chiefly in response to this request. The visit further afforded an opportunity to follow-up on earlier Academy activities in the country, and to meet with Peace Corps, United Nations, and Mauritaian officials.

Travelling from Dakar to Nouakchott with Peace Corps/Mauritania Director Jerry Stern, I was brought up to date on current Peace Corps program directions and areas for continued Academy support for their efforts in agriculture and rural development. Thusfar, such support has largely taken the form of Academy publications and seed. During this visit, additional copies of Tropical Legumes: Resources for the Future and Microbial Processes: Promising Technologies for Developing Countries were left with the Peace Corps staff. A substantial quantity of Melia azedarach (Indian lilac) seed was also left with the Peace Corps. Although generally regarded as an ornamental in the United States, this fast-growing, deciduous tree is drought resistant, provides wood for furniture making and fuel, and leaves which can serve as goat fodder. Interest was also expressed in drought resistant food crops. We are particularly interested in evaluating the performance of sixty-day maize (Zea mays) in the Sahel, and forwarded a small quantity of seed of the Harinoso de Ocho Pima-Papago race to Nouakchott soon after returning to the United States.

The following day, April 23rd, meetings were held with members of the USAID Mission staff, including geographer J. Rowland Illick, agronomist James Hughes, and Allen Reed. Meetings were also held with John Heermans, a forestry consultant retained by the Mission to write the reafforestation proposal; with Demba Samoussa of the Mauritanian Service for the Protection of Nature; and with Roger Conrad, Associate Peace Corps Director for Agriculture and Rural Development, and Peace Corps Volunteer Andy Linehan, stationed at Kaur Massène. The discussions dealt largely with possible

approaches to environmental rehabilitation in Mauritania and, to a lesser extent, with the possible role of the Peace Corps in such efforts—particularly in the Chemama.

During the morning of the 24th, a meeting was held with John Haarmans, Thaleb Diack, and Demba Samoussa at the offices of the Service for the Protection of Nature. The discussion covered a broad range of concerns: the comparative advantages of various native and exotic plant species, the importance of establishing a greater number of nurseries to support efforts in environmental rehabilitation, planting techniques, questions of water availability and application, and procedures for establishing livestock exclosures. Mr. Diack expressed the hope that the existing interest in dune stabilization could be expanded to include roadside plantings to protect highways from drifting sand. The discussion also touched upon the desirability of including conservation instruction in school curricula as a means of increasing awareness of environmental problems and sustaining rehabilitation efforts. In this connection, it was noted that the Ecole National Forestière Vétérinaire et Agronomique at Kaédi, the principal training center dealing with environmental issues, has no library and would profit greatly from the establishment of an arboretum. Commenting further upon training at Kaédi, Mr. Diack, a forester and a senior official in the Service for the Protection of Nature, indicated that greater emphasis should be placed upon practical experience. He was particularly concerned by the lack of such experience in Kaédi graduates continuing their forestry studies abroad. He feels that at

least two or three years of practical experience should be required of such students. Mr. Diack believes that it would contribute to the maturity of the student and allow him to better relate his theoretical knowledge to the realities of environmental and social systems.

It might be noted that Mr. Diack has for many years been accumulating information regarding the economic botany of Mauritania. Such information would be of vital importance for the reconstruction or rehabilitation of environmental systems and, in turn, pastoral systems and coping strategies based upon drought resistant natural products. It is certainly to be hoped that the value of Mr. Diack's survey will be recognized and the work encouraged.

During the afternoon of the 24th, a meeting was held with Mission Director John Hoskins, John Heermans, and J. Rowland Illick. The proposed reafforestation project in Mauritania would certainly be among the most ambitious in the Sahel, and Mr. Hoskins briefly explained the Mission's purpose in pursuing such an undertaking. The principal concern of the Mission is that the project be of sufficient scope that it might have a genuine impact upon the country. Mr. Heermans reported on his recent survey of the Trarza and Brakna regions, and visit to the Ecole Nationale Forestière Vétérinaire et Agronomique at Kaédi. On the basis of his recent observations, Mr. Heermans felt that immediate attention should be given to the problem of dunal encroachment at Magta Lahjar and in association with other barrages in the Brakna region. Academy activities in

Mauritania were summarized, with emphasis placed upon our interest in enviornmental rehabilitation rather than reafforestation per se, and hope that particular thought be given to relating the components of the proposed project to the dynamics of environmental systems, the seasonal movement of pastoralists, and the needs of agricultural populations. The formative elements of our concern are contained in an April 1979 ACOS staff summary report entitled "An Assessment of Agro-Forestry Potential within the Environmental Framework of Mauritania."

On Friday, April 25th, following further meetings with the Mission and with James Dickey, livestock advisor in USAID's Sahel Development Planning Regional Office, Roger Conrad, John Heermans, Demba Samoussa, and I left Nouakchott for a three-day field trip in southern Mauritania and northern Senegal. As the Nouakchott-Louga segment of the trip duplicated travel undertaken almost exactly one year earlier, it was possible to make some comparative observations regarding trends in environmental change along the route—albeit rather general observations. In purely quantitative terms, there was a net increase in aerial biomass. In part, however, this reflects the gains of "decreasers" and "invaders" at the expense of the more palatable species. Many of the observed trends can be somewhat deceptive, a situation which underscores the importance of evaluating vegetation with reference to development objectives, such as range improvement, and ecological processes.

Euphorbia balsamifera and Tamarix senegalensis were dominants along the margins of the Aftout as-Sahali. As we continued southward,

leaving the coastal depression and entering a zone of immobile and recently reactivated dunes, the Tamarix gave way to Acacia spp., including the gum-producing A. senegal. Date palms, Phoenix dactylifera, were encountered increasingly, along with a limited number of Adansonia digitata (baobab) and the more common Balanites aegyptiaca, Calotropis procera, and Parkinsonia aculeata. A surprisingly large number of forbs and shrubs were recorded throughout the coastal zone, including Mesembryanthemum spp., Salicornia spp., and Salvadora persica. Unlike the situation in April 1979, there was a relative abundance of standing Cenchrus biflorus, an important grass in carrying livestock late in the dry season after its spikelets fall. It might also be noted that a substantial amount of dormant seed was found in sifting through the sandy soil alongside the highway, a circumstance which, given proper species balance, could bode well for the region if the 1980 rains are adequate. It might be noted further that acacia regeneration seemed to be reasonably good, but that regeneration was less satisfactory for other tree species. (While it is perhaps belaboring the obvious, "good" regeneration reflects adequate seed supply and conditions conducive to germination. Survival is determined by a somewhat more complex set of variables.)

In terms of secondary environmental indicators, the bird life along the Nouakchott-Rosso segment of the route was generally limited to Galerida cristata (crested lark) in open country and omnivorous species such as Corvus albus (pied crow) and Turdus purpureus (purple glossy starling) around settlements such as Hassei el Gourdane. As we approached

Rosso and the Chemama, the diversity increased somewhat, reflecting the greater environmental diversity of the better watered south: Insectivorous species included Apodidae (swifts), Bubulcus ibis (cattle egret), Centropus senegalensis (Senegal coucal), Ceryle rudis (pied kingfisher), Coracias abyssinica (Abyssinian roller), Hirundinidae (swallows), Ipophilus obsoletus obsoletus (brown-backed woodpecker), Numida meleagris (helmet guinea-folw), Tockus nasutus (grey hornbill), Upupa senegalensis (Senegal hoopoe), and Hoplopterus spinosus (spur-winged plover). Granivorous species included Estrilda troglodytes (red-cheeked cordon-bleu), Lagonosticta senegala (Senegal fire-finch), Petronia dentata (bush-sparrow), Pterocles exustus (chestnut-bellied sand-grouse), Streptopelia decipiens (mourning dove), S. turtur (European turtle-dove), S. vinacea (vinaceous dove), and Treron waalia (Bruce's green pigeon). Relatively few birds of prey were recorded, although Cuncuma vocifer (fish eagle) was found along the Senegal River to the east of Rosso. The species balance was about what one would expect at this time of the year. The numbers, while by no means great, were somewhat in excess of those recorded in the same areas last year. Other forms of wildlife were scarce in the Mauritanian coastal zone. Our group sighted only one jackal, one mongoose, and a few ground squirrels. The relative absence of wildlife evidently reflects the widespread disturbance of habitat in the region.

With regard to non-biological indicators, there was relatively little erosion and deflation in the region transected. The highway itself, however, was plagued by dunal encroachment, and its shoulders

were in many sections dangerously reduced by erosion. The problem of encroachment is apparently related to devegetation and physical disturbance, the latter caused largely by the construction of the highway.

As we travelled toward Rosso, the occasional accumulations of sand on the highway reminded us of Thaleb Diack's concern for roadside stabilization. Perhaps sixty kilometres to the south of Nouakchott, the seriousness of the problem was dramatically underscored by an accident which had occurred moments before we arrived on the scene. A station wagon had gone out of control and rolled over, killing four of its occupants and injuring the driver. While it was difficult to determine the precise cause of the accident, a growing number are caused by drift sand and the abrupt drop from the highway surface to the reduced shoulder—the latter often resulting in tire damage. We administered first aid to the driver, awaited the arival of Mauritanian authorities, and continued to Rosso. With regard to possibilities for roadside stabilization, it is noteworthy that many of the plant species which already grow along the highway have been used successfully in dune stabilization projects elsewhere, particularly Acacia senegal, Euphorbia balsamifera, and Tamarix spp. Certain exotic species already established in the region, such as Prosopis chilensis and Parkinsonia aculeata, could be added for further stabilization and the addition of organic matter.

Upon arriving in Rosso, we met briefly with Lieutenant-Governor Moulaye and officials of the Service for the Protection of Nature.

Following these meetings, we entered Senegal and drove to Saint-Louis. Perhaps the most striking features of this segment of the trip were the dramatic increase in Parkinsonia aculeata (a New World species, suggesting that the increase is related to the inclusion of Parkinsonia in Senegalese forestry programs) and the stabilizing influence of the living fences of Euphorbia balsamifera found in the area. The ameliorative influence of the Euphorbia fences was particularly noticable in the excellent regeneration of native species, notably Acacia senegal, in their lee (the seedlings being protected from the desiccating dry season north-easterlies). It was also interesting to find camels browsing on the bitter foliage of Azadirachta indica (neem)—perhaps more a measure of availability than of palatability. Approaching Saint-Louis, the diversity of the vegetation increased substantially, particularly noticable being the increase in fruit trees, including the coconut palm, Cocos nucifera. Also striking were the living fences of Opuntia, a versatile genus little appreciated in the Sahel. The many marigots and niayes of the Saint-Louis area supported a diverse avifauna, adding species such as Casmerodius albus melanorhynchos (great white egret) and Nycticorax nycticorax (night heron) to the Chemama list.

Continuing toward Louga, we stopped to visit a plantation established near Rao by the German Forestry Mission. Prominently included were Acacia scorpioides var. adstringens, A. senegal, and A. seyal. Our visit was abbreviated by the necessity of reaching the regional office of the Senegalese Water and Forest Service at Louga before evening to inform

Abdoulaye Sène of our plans to visit Mbiddi and to secure route information. Upon arriving in Louga this was quickly done, and we proceeded north-eastwardly through Nguermalal to Kaur Momar Sarr and eastwardly beyond the Lac de Guiers, setting up camp for the night near a small Peul settlement.

The principal objective of our travel in Senegal was to relate the experience accumulated in the Senegalese sylvo-pastoral zone to the problems of Mauritania. Hence, a few environmental reference points might be useful for purposes of comparison. Geologically, the area between the Lac de Guiers and Mbiddi is a relatively low plateau composed of Tertiary (Oligo-, Mio-, Pliocene) clayey sands in which sandstone and argillaceous layers are intercalated. These are covered by stabilized aeolian deposits. Climatically, the area falls within the BWh (tropical and subtropical desert) region of the Köppen classification; the sub-regional designation "ferlienne" is often applied to the area within Senegal. Precipitation averages around 350 mm. per annum. With reference to vegetation, Balanites aegyptica and Boscia senegalensis appeared to be dominants; Adansonia digitata was prominent; and Cenchrus biflorus was overwhelmingly the most conspicuous grass in unprotected areas. The soils of the area seemed to be largely desert soils corresponding to the orthids of the United States Comprehensive Soil Classification System; to the isohumic brown (-red) soils of the ORSTOM system. The area is sparsely populated. According to the 1971 census, there are only some five individuals per square kilometre.

Because of reservations regarding the use of fencing in environmental rehabilitation projects in the Sahel, it is of some interest that fencing, in various forms, was encountered throughout the area. Stake fences, thorn fences, living Euphorbia fences, and three- and four-strand barbed wire fences were all seen in the area—albeit with the barbed wire fences usually associated with the projects of foreign donors (German and Canadian). Another conspicuous feature of the area was the general abundance of dead trees in certain sections. The high mortality rates of certain species would appear to be less directly related to drought than to age grading and heavy browse pressure on emergent seedlings. Given the apparent breakdown of replacement mechanisms, the impact of a major drought upon senescent stands would be predictable in physiological terms. It would seem that attention should focus upon the restoration of circumstances permitting seedling survival. Because this has not been done, many of the more desirable species succumb to use pressure and the vegetation becomes progressively degraded. The socially sensitive and creative use of livestock exclosures would seem to be basic to any successful strategy of enviornmental rehabilitation in the Sahel. In this regard, the observed acceptance and use of fencing in the region was encouraging, suggesting that rehabilitation efforts can be linked to existing knowledge and perceptions.

The dead trees, most of which had fallen, were clearly making important contributions to the ecology of the area through physical stabilization and the release of organic matter and nutrients. Within the area,

regeneration was good, and the overall health of the area was further reflected in the more abundant wildlife and diverse bird life. In addition to the various savannah species noted on pp. 7-8 above, a few less common species such as Bucowers abyssinicus (ground hornbill) and Psittacula krameri (Senegal long-tailed parrakett) were seen in the area.

On April 26th, we visited a German-supported nursey and garden at the village of Bowdé Doudal (=Mbar Toubab), and German plantations, one of Balanitas aegyptiaca and another of Acacia scorpioides var. adstringens, at the village of Vidau Thingoly (as heard). The project at Vidau Thingoly was of particular interest. The villagers are almost exclusively engaged in animal husbandry. They appreciated the employment opportunities introduced by the project, particularly because they provided an alternative to some of the young men who would otherwise leave the village to seek work elsewhere. The villagers were obviously struck by the contrast between the absence of vegetation outside of the exclosures and the abundance within, and were pleased to have dry season fodder so near at hand (as livestock are not permitted to enter the exclosure, the fodder is cut and delivered to the animals). Favorable comment was also made of the greater privacy afforded by the plantations.

While the plantations were obviously accepted and serving the village well, the villagers seem not to have been fully apprised of the donor's objectives or of the status of the plantations with respect to the

provisions of Law No. 64-46 of 17 June 1964 concerning the national domain. It appeared also that a bit more thought might have been given to species selection. Particular attention might have been directed toward additional species producing browse, bearing fruit, or producing economic and medicinal products. It might be suggested further that the village would profit even more from the plantations were they situated to the north-east of Vidau Thingoly to intercept dry season winds and, in turn, prevent the encroachment of drift sand and facilitate seed scatter over the currently denuded areas in and around the village.

Continuing, we stopped briefly at the Galena well and proceeded to Mbiddi, arriving late in the morning. At Mbiddi, we met with Senegalese Water and Forest Service agent Etienne Manga, visited the nursery, and toured the plantation. Efforts at Mbiddi have apparently focussed upon gum-arabic production (Acacia senegal) and the selection of forage species. The International Development Research Centre (IDRC) has supported much of the gum-arabic research. They are particularly well positioned to do so since A. G. Seif-el-Din, formerly the Senior Gum Research Officer for the Sudan, joined the IDRC staff. The forage species trials were limited to such local species as Acacia scorpioides var. adstringens (=A. adansonii) and A. seyal, and to Australian species such as Acacia tumida, A. holosericea, and A. aff. linaroides. It is of possible interest that the performance ranking of the same Australian acacias at the UNDP plantation near Kébémer is reversed at Mbiddi—with A. aff. linaroides performing particularly well and A. tumida and A. holosericea less well,

or so it seemed. Should this in fact be the case, it might well reflect the marked differences between the atmospheric humidity and available ground water at the two sites.

With Mr. Manga, I discussed the possibility of Mbiddi involvement in the further testing of drought-tolerant trees and shrubs for use in agro-forestry systems and efforts in enviornmental rehabilitation in the Sahel. As do other Water and Forest Service officials, Mr. Manga feels that the station has both the interest and capacity to do so. It would appear, however, that for the trials to be undertaken on a large scale, it would be necessary to increase donor support beyond existing levels. Perhaps the proposed trials would be of interest to Peace Corps foresters.

Upon leaving Mbiddi, we drove northward to the Senegal River, westward through Dagana and Richard-Toll, and re-entered Mauritania at Rosso. At Rosso, we met with Protection of Nature agent Abou Diop, and then proceeded eastward along the Senegal River toward Bogué. We camped along the river to the east of Jeder el Mohguene, and continued on April 27th to a point some ten kilometres beyond Tékane. We had intended to revisit the principal area of charcoal production seen in the course of our April 1979 travels, an area located near the village of Dar al-Barka, but Mr. Samoussa, the Protection of Nature agent accompanying us, insisted that we had seen the most important features and activities of the region and asked that we return to Rosso. His insistence was of interest in the light of reports which indicate that some high ranking Protection of Nature officials are illegally

profiting from the charcoal trade, a situation which would further compound an already complex problem.

By comparison with our April 1979 observations, the intensification of gullying in devegetated areas along the River was particularly striking. One might assume that more subtle forms of erosion, such as sheet wash, were also affecting the area. Not only is the productive capacity of the land apparently being reduced, the silt load of the River is being substantially increased, and this increase will almost certainly have far-ranging implications for the downstream components of the OMVS project.

While it is obviously difficult to draw definitive conclusions on the basis of brief April visits in 1979 and 1980, the priorities of the Chemama do seem to have emerged with greater clarity. The general conclusions and recommendations of the April 1979 ACOS report, "An Assessment of Agro-Forestry Potential within the Environmental Framework of Mauritania," remain valid. It would appear, however, that reafforestation efforts might proceed more explicitly along FLCD lines and should initially focus upon those areas most severely damaged by erosion.

Following our travel, we returned to Nouakchott and spent the duration of the visit preparing recommendations for the reafforestation PID and meeting with USAID, Peace Corps, and Mauritanian officials. This final round of meetings involved Mission Director John Hoskins, James Dickey, Mona Fikry, John Grayzel, James Hughes, J. Rowland Illick, Allen Reed,

and Sally Sharp of USAID; John Heermans, Roger Conrad, and various Peace Corps Volunteers; Thaleb Diack and Fadel Touré. A rather detailed ACOS staff report, "Notes and Comments Regarding Proposed USAID/Nouakchott Efforts in Reafforestation" (May 1980), has been prepared and submitted to the Mission. Copies are available for further distribution.

Returning briefly to Dakar, an additional meeting was held with Erv Berglund regarding the possible contribution of various North African Plant species to forestry and agro-forestry efforts in the Sahel. Dr. Berglund, a University of Minnesota forester, has recently spent three years in Morocco. While in Morocco, he provided Argania sideroxylon (=A. spinosa) seed for trial plantings in the Mauritanian Adrar and has offered to secure additional seed for future ACOS program activities. A meeting was also held with Robert Winterbottom, a member of the Ecology Team of the Permanent Interstate Committee for Drought Control in the Sahel (CILSS). Mr. Winterbottom was en route to The Gambia in connection with a Sahel Institute effort to determine the status of environmental programes in the Sahel. Further information regarding this effort can be found in the ACOS staff summary report, "Workshop on Ecology and Environmental Programs in the Sahel" (January 1980).

Proceeding to Switzerland, a series of meetings were held at the offices of the International Union for Conservation of Nature and Natural Resources (IUCN) at Gland. Those with Pierre Hunkaler dealt largely with the potential contribution of the World Conservation Strategy to development efforts in

West Africa and cooperation with the IUCN's Commission on Environmental Planning. Discussions with Harold Eidsvik focussed upon the distribution of protected areas in relation to the needs of biotic community conservation in West and Central Africa; those with John Kundaeli dealt with the better integration of conservation with development activities in order to effect more sustainable development. Dr. Kundaeli was particularly concerned with development efforts in the Gambia River Basin and with scientific networking in relation to IUCN concerns in West Africa.

Continuing to Paris, meetings were held during the weekend with Jean Gorse, who had completed his World Bank assignment in Senegal, and with Laurent de Nazelle, formerly a French technical advisor dealing with problems of agricultural development in the Senegal River Basin. Count de Nazelle finds himself in basic disagreement with development policies affecting the Basin. He feels that development efforts in the Basin have been economically unsound, environmentally destructive, and socially disruptive. He feels that such efforts should be better attuned to local environmental and social realities and that steps should be taken to assure that the farmers and herders of the region are the principal beneficiaries of their own efforts.

On Monday, May 5th, a meeting was held with Arthur Fell of the Club du Sahel Secretariat. The purpose of the meeting was to review Club and Academy activities in the Sahel, and to improve communications between the Academy and the various private, national, regional, and international bodies involved in development efforts in the region.

The trip was concluded with my return to Washington during the afternoon of May 5th.

APPENDIX IV

Sahel Regional Aid Planning and Coordination
Contract AID/afr-C-1354
Expenditures

March 1, 1980 - August 30, 1980

Salaries and Wages		
Professional	$20,900	
Secretarial - Clerical	7,681	$28,581
Fringe Benefits		5,924
Consultants		1,000
Travel		
Domestic	(107)	
International	21,059	20,952
Communications and Shipping		917
Materials and Services		837
Indirect Costs		23,128
TOTAL		$81,339