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Advisory Committee on the Sahel

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NATIONAL ACADEMY OF SCIENCES-NATIONAL RESEARCH COUNCIL

Washington, D.C.

ADVISORY COMMITTEE ON THE SAHEL (ACOS)

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Introductory Note

There is a consensus among Sahelian officials and within the donor community that the environmental rehabilitation of the Sahel is a matter of particular urgency. The environmental focus of our contractual scope of work and the program recommendations of the February, 1979 meeting of the Advisory Committee on the Sahel (ACOS) reflect this consensus. During the period covered in this report, our efforts have related chiefly to critical, initial interventions believed necessary to stem the progressive deterioration of Sahelian environmental systems. ACOS activities have been proposed or undertaken in the following areas: the promotion of urban fuel-wood and construction-material plantations; agro-forestry; and resource management.

Urban Plantations

Perhaps no single aspect of the Sahel's precarious environmental status has received greater attention than the emerging fuel-wood crisis. It has been maintained, for example, that at present rates of deforestation Senegal will be devoid of trees in thirty years. The social and environmental implications of an even substantially more moderate estimate would be catastrophic. ACOS encouragement of irrigated urban plantations is premised in the belief that such plantations would constitute specific, achievable interventions capable of significantly altering the parameters of the overall environmental equation.

From N'Djamena to Nouakchott, meeting growing urban energy requirements with firewood and charcoal has become a critical factor in accelerating environmental imbalance in rural areas as trees and shrubs are cut over progressively wide areas. Hence, the creation of urban plantations would permit a reduction of the deforestation pressure upon such areas. In most rural areas, the removal of urban demand coupled with natural regeneration would result in the availability of fuel wood sufficient for local needs. Further, it would allow a reassessment of rural needs and the elaboration of more economical and effective village-level interventions contributing further to environmental stability.

A review of existing and proposed urban greenbelt projects in the Sahel, as well as discussions with Sahelian, French, and British foresters long familar with the region, indicated that the most appropriate ACOS contribution would be in the area of species selection. It is evident that many "failures" in plant introductions in the Sahel have resulted from such circumstances as site selection, seed provenance, slow initial growth, the failure to inoculate exotic legumes, and improper nursery techniques rather than intrinsic problems of genetic suitability. Furthermore, BOSTID's Advisory Committee on Technology Innovation (ACTI) has recently undertaken an international species search in connection with its fuel-wood study. Hence, utilizing the dryland listings of the ACTI study as an immediately available initial baseline (subsequently critiqued and expanded), we have been able to suggest to Sahel government and technical assistance agency officials the reconsideration or consideration of a broad range of promising species.

Additional attention has been devoted to potential benefits to be derived from complementarity among different species groupings. For example, the per unit productivity of many plantations could be enhanced by combining species with potentially very rapid growth, such as Eucalyptus tereticornis, with similarly vigorous, well incculated leguminous companions such as Leucaena leucocephala. Both species produce fuel wood of high quality, and the nitrogen fixation of the leucaena would not only accelerate the growth of the eucalypt but would compensate for nutrient depletion by the eucalypt and thereby reduce the total area necessary to support a sustained-yield operation. The latter point is noteworthy in connection with management considerations and reduced interference with existing tenure systems.

A joint workshop addressing urban plantations was proposed to and accepted by Eaux et Forêts/Senegal. It was understood that the effort would contribute directly to the Greenbelt Fuelwood Project proposed by USAID/Dakar. The workshop, scheduled for April, was postponed indefinitely at the request of the USAID Mission. Fortunately, both in terms of the investment of time in preparation and the commitment of highly qualified experts, the activity was shifted to Mauritania under the sponsorship of USAID/Nouakchott. Within the Mauritanian context, however, the urban-plantation theme was subordinated to a more general consideration of agro-sylvo-pastoral systems.

Our principal collaborators in the development of the urban-plantation activity were Robert Fishwick and Jean Gorse of the World Bank, E. Gerry Hawkes of Woodland Balance (Woodstock, Vermont), Gilles Lessard of the

International Development Research Centre, Michael McGahuey of CARE-Chad, Hans-Jurgen von Maydell of the Institute of World Forestry (Hamburg, West Germany), François Mergen of Yale University, El-Hadji Sene of Eaux et Forêts/Senegal, Fred Weber of the International Resources Development and Conservation Service (Boise, Idaho), J. L. Whitmore of the Institute of Tropical Forestry (Rio Piedras, Puerto Rico) and Robert Winterbottom of the Comité Permanent Interétats de Lutte contre la Sécheresse dans le Sahel (CILSS). The USAID/Washington coordinator for the activity was forester Thomas Greathouse.

Agro-forestry

Working discussions devoted to agro-forestry and fuel-wood supply were held 23-28 April 1979 in Mauritania among a panel of NAS/BOSTID experts, Mauritanian government and USAID mission officials. The summary report, entitled "An Assessment of Agro-Forestry Potential within the Environmental Framework of Mauritania," is attached as Appendix I. In addition to the assistance of those individuals cited in the preceding paragraph, further information and advice concerning the agro-forestry focus of the workshop was drawn from Kenneth King of the Nairobi-based International Council for Research in Agro-Forestry (ICRAF), Cyrus McKell of Utah State University, and Noel Vietmeyer of BOSTID's Advisory Committee on Technology Innovation. The Academy panel for the working discussions in Mauritania included Jean Gorse of the World Bank, François Mergen, Gary Nabhan of the University of Arizona, Brien Norton of Utah State University, and Robert Winterbottom. The activity was staffed by Michael Dow and Jeffrey Gritzner of BOSTID.

In the course of the activity, members of the panel visited the six major ecological zones, and following discussions with local government officials preliminary environmental assessments were made. Attention was then directed toward the related considerations of public education, conservation practices, improved water use in connection with agro-forestry, and plant-species selection. With regard to species selection, particular attention was directed toward the identification of species suitable for fuel, construction, food, and fodder, especially toward multiple-use species requiring little or no irrigation. Further attention was directed toward dryland economic species such as jojoba (Simondsia chinensis) and guar (Cyamopsis tetragonoloba). This latter component of the effort was initially encouraged by Sahelians (largely Senegalese) who had become familiar with the Academy through participation in the preparation of, or through the receipt of, BOSTID publications such as Underexploited Tropical Plants with Promising Economic Value, The Winged Bean, Guayule, Leucaena, and Tropical Legumes.

Mauritanian government (GIRM) initiatives emerging from the discussions included the following: All Mauritanian citizens were encouraged to plant a tree on August 1st. Seedlings, principally mesquite (Prosopis chilensis), were provided by the Nouakchott greenbelt nursery for planting in and around Boutilimit, Nouakchott, and Rosso. In other areas, neem (Azadirachta indica) and acacia seed was provided for the occasion. The project was reinforced by an educational campaign dealing both with the care of the trees planted and, more generally, with the role of the citizen in combatting environmental deterioration. This campaign was promoted by the radio, the press, and by mobile brigades of mounted cameleers trained by the Ministry of Rural Development's

Service for the Protection of Nature. It was further reinforced by the dissemination of supportive statements made by Ba Oumar, Minister of Rural Development, and by various members of the ruling Military Committee for National Welfare (CMSN).

An August-September BOSTID staff visit to Mauritania revealed that the tree-planting project and its attendant educational campaign have been most successful. Large numbers of newly planted seedlings were evident in the environs of Nouakchott and, contrary to our observations in April, GIRM restrictions regarding the cutting of living trees were being scrupulously observed in rural areas, a circumstance perhaps related to explicit CMSN support for environmental rehabilitation.

In addition to the above, the recommendations led to a decision by the government to establish tree nurseries in each regional capital with an initial total capacity to produce 100,000 seedlings per annum for use in the national effort in revegetation; to the possibility that the CMSN will declare a thirty-kilometer-deep zone around Nouakchott as an environmentally protected area in order to stem degradation around the capital; and to expressed interest in amending or eliminating laws which are inconsistent with the sound management of environmental systems. Many of the preceding GIRM initiatives are summarized in USAID cable Nouakchott 2227.

In consultation with the GIRM, USAID/Nouakchott developed an accelerated impact project based upon the Academy findings and recommendations. As described in USAID cable Nouakchott 1695, the project was originally to have included "1) 100 hectares to be planted with a variety of tree seeds to learn which would be most suitable for firewood resources; 2) support for nursery/ forestry activities at the Kaedi Agricultural School; and 3) support for the

experimental farm/nursery at Nouakchott." Regardless of the uncertain status of the project, its formulation served to indicate to Mauritanian officials that USAID recognized the seriousness of the environmental emergency in Mauritania and was prepared to join the government in addressing it.

The Academy's response to the recommendations has included the identification of some 210 plant species potentially capable of contributing to Sahelian agro-sylvo-pastoral systems. As of September 1979, seed for forty-six of the species had been distributed in Mauritania and was undergoing controlled trials in connection with the programs of the Lutheran World Federation, the Mauritanian agricultural school at Kaedi, and USAID/Nouakchott. Seed distribution is being coordinated by Gerrit ten Velde of the Lutheran World Federation. In addition to the provision of seed, the recommendations to the GIRM and to USAID/Nouakchott have been further supported by the distribution of relevant BOSTID publications (see Appendix II) and the Volunteers in Asia volume, Lorena Owner-Built Stoves (an acknowledgement of the important role of fuel conservation in environmental rehabilitation).

The experience accrued from the discussions is directly relevant to other regions of the Sahel (with the partial exception of that focussed upon the sub-Canarian coastal zone). In this regard, discussions were subsequently held at the Sahel Institute at Bamako, Mali. The discussions included a general description of the Mauritania assessment and agreement to cooperate with the Institute in the area of environment/ecology (which includes agroforestry within the Institute structure). This agreement included a proposed joint evaluation of the Institute's program in environment/ecology in June (see Appendix III, pp. 5-6). Unfortunately, the evaluation was postponed

because of an inability to coordinate our schedules. It has been tentatively rescheduled for the second week of November. A more comprehensive ACOS agro-forestry workshop, which we hope will be co-sponsored by the International Council for Research in Agro-Forestry and the Sahel Institute, has been tentatively scheduled for July 1980.

The integrative nature of agro-forestry is particularly attractive as an alternative to monoculture farming systems. Not only does it circumvent the somewhat artificial separation of agricultural and sylvicultural concerns, it allows stable, integrated systems of production to emerge genetically from existing patterns of land use without the social and environmental dislocation which characteristically accompanies introduced systems of agricultural production. The inclusion of proven, high-value economic species such as jojoba and guar in agro-forestry systems would permit Sahelian agriculturalists to generate additional income without having to resort to less adaptive economic strategies.

Resource Management

Unlike the more narrowly focussed efforts such as the promotion of urban plantations, efforts to promote environmental restoration on a larger scale presuppose an understanding of the species composition of preexisting natural systems; the internal dynamics of those systems; and appropriate techniques and strategies for accomplishing project objectives.

The ACOS staff has undertaken an overview of the Pleistocene ecology, palynology (fossil spores and pollen), and historical change within the environmental systems of the Sahel. Not surprisingly, the results of

the overview suggest relative long-term bioclimatic stability; reveal substantial "gaps" in existing biotic communities, implying the disruption of energy flow within those communities; and indicate that the "native" vegetation of the Sahel represents a degraded subclimax of which only approximately twelve per cent of the species are native. In order to further clarify the bioclimatic context of current development efforts in the Sahel, the ACOS staff has suggested the establishment of a panel chaired by Karl Butzer of the University of Chicago and charged with the synthesis of baseline information for the rationalization of efforts in revegetation. The meeting has been tentatively scheduled for July 1980.

According to current ecological theory, the stability of a biotic community is a function of its species diversity. The more diversified the flora and fauna, the less the likelihood that any major event would adversely affect the system as a whole. It follows that the progressive simplification of Sahelian biotic communities has measurably increased the vulnerability of the region's inhabitants, livestock, and wildlife to the ravages of drought. Hence, in addition to more conventional assessments, the ACOS species search is increasingly exploring unconventional categories of drought-tolerant plants which both contribute to species diversity and are able to sustain human and animal populations during periods of scarcity. Such species would include the marama bean (Tylosema esculentum) and the jicib bean (Cordeauxia edulis), wild African legumes which have long served as emergency foods and which, during periods of normalcy, contribute to environmental stability both as ground cover and through nitrogen enrichment. Other marginally unconventional categories would include tree or shrub species,

such as Arbutus andrachne and Delonix regia, of potential importance in connection with honey production--both because of the importance of bees in pollination (and therefore in regeneration) and because of the high value assigned to honey by Sahelian populations; species such as Acacia cyclops and Calligonum comosum which are of particular value in binding coastal or inland dunes; species, such as Tamarix aphylla, which can serve as green firebreaks; and species with other desirable characteristics, such as those which regenerate vigorously; which are salt tolerant; which possess important nutrients; which are appropriately palatable (or in some instances non-palatable); or which are unusually adaptable. For a variety of reasons, the ACOS is attaching considerable importance to the potential contribution of browse shrubs, such as Atriplex canescens, in rehabilitating distrubed lands in the Sahel. Our principal collaborator with regard to the selection of shrubs is Cyrus McKell, Director of the Institute for Land Rehabilitation at Utah State University.

In some instances, the ACOS staff has identified particular unconventional species which appear to offer attractive development possibilities in the Sahel. Such would be the case, for example, in the instance of Spirulina spp. Spirulina is a filamentous blue-green alga which, under Sahelian conditions, increases at an average rate of 12 g/m^2 per day (as compared with 1.6 to 3.8 g/m^2 per day for dense tree or crop stands). Further, it can thrive in brackish (to 14,000 mg/liter of chloride) and alkaline (to pH 11) waters. The crude protein percentage of Spirulina is reported to be as high as 72 percent (dry weight) with a satisfactory balance of essential amino acids

(compared with a protein percentage of 12 per cent. for sorghum; 7 percent for rice). The alga is easily managed and recovered, is readily accepted by Sahelian populations (it has long served as a dietary item in the Lake Chad basin), and elsewhere has supported livestock industries in marginal areas.

The potential of Spirulina has been briefly described in the BOSTID publication, Underexploited Tropical Plants with Promising Economic Value (1978 revised), and a possible conduit for ACOS interest in Spirulina has emerged in the form of the Foundation for Microbiology following correspondence and discussions with Byron Waksman of the Foundation and Yale University. Dr. Waksman had contacted BOSTID expressing interest in supporting a research project in Africa which would be socially beneficial and would provide professional training for African microbiologists. The further development of Spirulina as an inexpensive source of high-quality protein for the Sahel represented a project possibility which related well to the resources and interests of the Foundation. Discussions concerning the potential contribution of Spirulina to development in the Sahel were proposed to USAID/Niamey for August 1979. As travel authorization was not granted, the ACOS has proposed that the discussions be re-scheduled for 31 January 1980.

Another example of special attention being focussed upon a particular resource might be drawn from the realm of soil ecology. Under normal circumstances, soil organic matter contains most of the reserve nitrogen which becomes available to plants. Hence, soils low in organic matter are correspondingly deficient in nitrogen. The soils of the Sahel are characteristically low in organic matter, a condition aggravated by a progressive reduction of biomass. A high proportion of plants adapted to desertic conditions are

leguminous. In legumes, root-nodule bacteria of the genus Rhizobium, through a symbiotic relationship with the plant, "fix" atmospheric nitrogen which then becomes available for plant growth. In addition to directly benefiting particular legumes and their companions, these microbial transformations are essential to the completion of the nitrogen cycle in arid- and semi-arid regions and are, therefore, essential to environmental rehabilitation in such areas.

The ACOS has established a highly constructive working relationship with the curators of the Rhizobium collection at USDA/Beltsville, Harold Keyser and Deane Weber, and with Rhizobium expert Lloyd Frederick of USAID/Washington (DS/AGR). These relationships have permitted, for example, a microfloral analysis of soil samples taken from the Nouakchott, Mauritania greenbelt, and hopefully will lead to the establishment of a freely accessible Rhizobium collection in Sahelian West Africa. The establishment of the collection is to be discussed in Senegal in connection with a scheduled ACOS presentation at a November CILSS soil-conservation workshop at Dakar. That portion of the ACOS program devoted to Rhizobium will be presented by Dr. Keyser. Interest in the potential contribution of soil microflora to regional development is rapidly increasing in the Sahel and, in the opinion of World Bank forester Jean Gorse, the establishment of a Rhizobium collection might well prove to be the most important single contribution to forestry and agricultural projects in the region. A description of the importance of Rhizobium to the growth and productivity of leguminous plants appears in the BOSTID volume, Microbial Processes (in press).

Our initial concerns in resource management have focussed upon plant-soil relationships because of the primacy of these relationships within the Sahelian ecology. While we expect to retain this emphasis, we also hope to extend our activities into the realm of wildlife management. Early initial attention has been directed toward the management of addax (Addax nasomaculatus) and oryx (Oryx dammah) populations in the northern Sahel above the 150 mm isohyet. There are many reasons to direct more attention toward the maintenance or restoration of wildlife populations: Because wild species occupy distinct and usually complementary ecological niches, the standing biomass of wild species characteristically exceeds that of domesticated livestock subject to the same conditions, sometimes exceeding livestock by a factor of five. Therefore, the carrying capacity of grazing resources is much higher for wildlife than for cattle. Lee Talbot has noted, for example, that an area of acacia savannah carrying 19.6 to 28.0 kg/ha. of cattle can carry from 65.5 to 157.6 kg/ha. of wild ungulates. Wild ungulates such as addax and oryx also exploit vegetation in a catenary succession, thus allowing the fullest possible use of available forage. Further, wild ungulates are more ecologically adaptive than livestock in terms of their tolerance of stress and disease and their greater efficiency in the use of water resources. The oryx, for example, can survive using only water consumed while eating grasses and browse. Wild animals also provide more meat per live weight and more of this is protein-yielding lean meat rather than high calorie fat.

In addition to the importance of the addax and oryx as highly productive sources of food, there are other reasons to consider the management of wildlife populations. Within the realm of Sahelian societies, wild animals often

play important roles in systems of religious or tribal belief. In other instances, certain species have served as the principal source of sustenance for entire tribal groups. For example, the Nemadi of Mauritania were almost wholly supported by the addax of the Majabat al-Koubra. The decline in addax populations caused by uncontrolled commercial and sport hunting has been accompanied by the almost total destruction of Nemadi society. Wild ungulates also serve as active agents of revegetation by consuming seed, transporting it, and depositing it upon elimination. Many of the plant species of the Sahel, particularly large-seeded species such as those of the genera Acacia and Prosopis, are designed to be dispersed by browsing ungulates. Not only does domesticated livestock fail to adequately substitute for wildlife in this process, it frequently contributes to reduced wildlife numbers through habitat modification and direct completion. Recent ACOS recommendations to Hartmut Jungius, Project Screening Coordinator of the International Union for Conservation of Nature and Natural Resources/ World Wildlife Fund (IUCN/WWF), have underscored this neglected fact. Finally, sound wildlife management programs can provide sources of income for Sahelian countries through controlled trophy hunting, a source relatively unaffected by vagaries of precipitation.

Recent discussions concerning the potential importance of wildlife in development planning have been held with Robert Winterbottom of the CILSS; Barbara Lausche of the International Institute for Environment and Development; Jacques Berney, Harold Eidsvik, Pierre Hunkeler, and John Kundaeli of the IUCN; Cheikh Lamine of the Mauritanian Ministry of Rural Development;

Richard Blue, Abraham Hirsch, and J. Rowland Illick of USAID; and John Newby of the World Wildlife Fund. The ACOS staff has tentatively scheduled discussions concerning the management of arid-zone wildlife resources for February 1980 at Ouagadougou, Upper Volta. Discussants would include members of the CILSS Ecology Team.

Other endangered animal species in the Sahel deserve prompt and thoughtful consideration. Among them would be the various crocodile species of the region: Crocodylus niloticus and, perhaps, C. cataphractus.

In March 1979, on the advise of USAID/Dakar consultants, R. Schillinger, a World Bank technician attached to the Planning Unit of SOMIVAC in the Senegalese Ministry of Rural Development, contacted Wayne Marion of the University of Florida and Howard Campbell of the U.S. Fish and Wildlife Service (and Chairman of the IUCN Crocodile Specialist Group) regarding the possibility of establishing a crocodile management program in the Lower Casamance. Conversant with the active interest of BOSTID's Noel Vietmeyer in the Papua New Guinea approach to crocodile management, Dr. Campbell relayed Mr. Schillinger's request to the Academy.

The Papua New Guinea approach to management promotes environmental stability in order to maintain breeding populations in the wild. From these populations, a number of young crocodiles are captured and raised in captivity for their hides, thus generating substantial economic activity in marginal riverine lowlands presently possessing few viable economic options. The IUCN and many other conservation groups have endorsed this approach both because it conserves endangered species and because it implies the maintainance of habitat. The participating governments of developing countries endorse it because it generates much higher levels of economic activity at lower levels of risk than existing alternatives, such as irrigated agriculture. As initially pointed out to the

ACOS by David Shear, presently USAID/Dakar Mission Director, this approach to crocodile management also has a beneficial impact upon inland fisheries yields: The crocodiles feed largely upon coarse fish which, with predator removal, increase at the expense of favored genera such as Tilapia.

Discussions regarding the appropriateness of the Papua New Guinea management approach have been held with Dr. Campbell, John Kundaeli and Jacques Berney of IUCN, Wayne King of the Florida State Museum, environmental lawyer Barbara Lausche, Donald Plucknett of USAID/Washington, Hugh Popenoe of the University of Florida, and Noel Vietmeyer of BOSTID. Dr. Vietmeyer has recently described the Papua New Guinea approach in the FAO journal, Ceres, and in a lecture exploring underexploited village resources at the Royal Society, London. An excerpt concerning the Papua New Guinea approach to crocodile management from Dr. Vietmeyer's Royal Society address appears as Appendix IV of this report.

In addition to the wild species of the Sahel, more attention might also be directed toward promising domesticated species capable of satisfying acknowledged needs.

In the course of July 1978 discussions, President Dawda Jawara asked that the ACOS explore possibilities for increasing milk production in The Gambia, a country severely affected by trypanosomiasis. In travelling through other regions of the Sahel, it is always striking, and perhaps somewhat ironic, that these important beef-exporting states are themselves major importers of expensive dairy products. Our response to President Jawara and to chronic milk deficiencies in the Sahel, has been a suggestion that the Asiatic water

buffalo be introduced on a trial basis in order to (i) test the buffalo for resistance to trypanosomiasis, and to (ii) provide the region with an alternative source of milk, beef, and traction. This implies the establishment of from two to four herds in order to test the animals within differing environmental contexts (and, hence, differing sustenance, pathogens, etc.). The suggestion has been greeted with enthusiasm by many Sahelian officials and donor bodies.

The following is excerpted from Dr. Vietmeyer's recent presentation at the Royal Society:

> The water buffalo (Bubalis bubalis) is not treated in university courses and the majority of scientists, farmers, veterinary advisors and agricultural administrators are unfamiliar with it. Some, whose careers are invested in the development of other animals, even feel threatened by it. But thanks to the foresight of a small band of adventurers and animal scientists, there is a growing recognition of the water buffalo's promise.
>
> The humble water buffalo, normally considered fit only for steamy rice paddies of Asia, is now getting a chance to prove itself elsewhere.
>
> Some non-Asian nations are already capitalizing heavily on the water buffalo's promise; Brazil, for instance. A few animals imported from India into the Amazon region 40 years ago have multiplied to about 400,000 head and are increasing at about 10 percent annually. Buffalo meat and milk now sell well in Amazon towns and villages, the meat for the same price as beef. One author claims that a two-year-old buffalo gives more meat than two cows of the same age. Nearby countries such as Venezuela and Trinidad are following Brazil's lead, and Colombia and Guyana are now testing water buffalo, too.
>
> On the other side of the Pacific, Papua New Guinea has found the water buffalo ideally suited to the difficult environment on its north coast. For nine years, the government unsuccessfully tried to run cattle on the Sepik and Ramu plains. Then a few years ago, it introduced water buffaloes. They have performed spectacularly, producing more calves and much more meat thant the cattle they are with. Papua New Guinea has since imported hundreds more buffaloes from Northern Australia and now has thriving herds totaling almost 2,000 head.
>
> Perhaps the water buffalo's greatest advantage is that it can thrive where straw or coarse, unpalatable grasses are the only forages available. It seems able to produce meat from tasteless, dry grasses that are inadequate to support cattle.

This observation, however, is not widely known even among researchers. Indeed, although proponents of various breeds of cattle are found worldwide, the water buffalo--which is not a cow--has received little but scorn from scientists and cattlemen alike. Because of this, most generalizations made about buffaloes are myths based only on prejudiced speculation.

For instance, it is widely reported that water buffalo meat is tough and less desirable than beef. But it is actually lean and tender. In taste preference tests at the University of Queensland in Australia that compared buffalo steaks with those from Angus and Hereford breeds, the buffalo meat came in first and seventh out of 40 cuts tasted by the panel. Buffalo meat has topped beef in taste trials in Malaysia and Trinidad, too.

Another water buffalo myth is that the animal is vicious and unpredictable. However, the truth is that unless it is wild, wounded or severely stressed, it is probably the gentlest farm animal in the world. Despite an intimidating appearance, buffalo are more like household pets. Sociable, genial and serene by nature, they have a natural fondness for humans.

Other blatantly false statements include the often heard comments that:

- water buffalo can be raised only near water. Not so. Though they love wallowing, buffaloes grow and reproduce normally without it.
- the water buffalo is exclusively a tropical animal. False. They have been used to pull snow plows during Bulgarian winters.
- the water buffalo is just a poor man's beast of burden. Again, not true. In addition to providing fine lean meat, buffaloes produce smooth, rich milk with twice the butterfat of cows' milk. Mozzarella, long one of the most popular cheeses in Europe, is made from milk of the 40,000 water buffalo farmed in the lowlands near Naples, Italy.

This pervasive collection of untruths has inadvertently turned farmers and scientists away from water buffalo. However, the performance of this unpretentious animal has been so outstanding in such unexpected places as Bulgaria, Italy, Papua New Guinea, Venezuela, Trinidad and Brazil that it seems destined for much greater use in villages and farms throughout the tropical, sub-tropical and warm temperate zone.

In order to further assess the potential of the water buffalo, BOSTID held a 16-18 July 1979 workshop at Gainesville, Florida. A list of participants is attached as Appendix V.

A brief article concerning the water buffalo, written by Dr. Vietmeyer, appears in the October 1979 number of the USAID journal, Agenda.

At the present time, the ACOS interest in existing Sahelian livestock programs is largely restricted to range rehabilitation. In many instances it has become clear that discussions dealing with increased livestock production have paid scant attention to the environmental implications of that increase. In addition to the considerations of species selection noted above, the ACOS is paying particular attention to the nature, scale, and geographical distribution of projected efforts in revegetation. Accepting existing social structures as management systems, we are currently more concerned with the reinforcement of existing land-use patterns than with the institution of experimental and often highly disruptive alternatives.

In suggesting a variety of project designs and distributions, the ACOS intends to better reconcile range-use patterns with the regenerative dynamics of Sahelian environmental systems. In these designs, the animal units themselves often serve as agents of revegetation, thus compensating for the grazing/browsing pressure applied. An example, briefly stated, would be the establishment of protected reserves in association with the principal watering points of the Sahel, areas which are conventionally centers of degradation. The collection and feeding of the seed pods of the Acacia spp., Prosopis spp., and similar species within the reserve to livestock would allow the modification of the seed by the digestive processes of the animals (the seeds are not themselves digested) and rapid germination upon elimination. Hence, the animals would contribute to revegetation in what have in recent years become the coalescing cones of environmental abuse associated with "desertification." These protected areas would also reduce soil compaction near wells, the associated vegetation would facilitate the interception and

infiltration of precipitation (thus better maintaining water levels in wells), the areas could serve as fodder reserves during periods of drought; serve as laboratories to observe natural regeneration, as test plots to experiment with new methods of revegetation, serve as seed sources for natural revegetation, as foci of genetic enrichment through the introduction of exotic plants (on a scale which would facilitate the inoculation of introduced legumes), serve as refuges for wildlife, etc.

The April agro-forestry working discussions in Mauritania led to a series of recommendations related to large-scale land reclamation. These recommendations, coupled with similar concerns in other quarters of BOSTID, led to a "Study on Non-Conventional Techniques and Species for Land Reclamation" held in June. Although this study (as was also the case with the water buffalo discussions at Gainesville) was not funded through the Sahel contract, information regarding seminar participants and topics is attached to this report as Appendix VI. It is felt that some of the techniques discussed are directly relevant to problems in the Sahel, and it is hoped that the ACOS will be able to generate large-scale efforts which are complementary to more traditional forestry and range-management approaches.

A discussion of various techniques and species appropriate to land-reclamation in the Sahel is to serve as a second ACOS contribution to the November CILSS soil-conservation workshop at Dakar. Responsibility for the contribution has been assigned to Wilbur ("Bill") Currier, an expert in vegetative rehabilitation and rangeland equipment living in retirement at Albuquerque, New Mexico.

A final ACOS activity has grown out of a May NAS Climate Research Board study on the "Effective Use of Climate Information in Decision-Making." A group composed of Francis Bretherton of the National Center for Atmospheric Research, Jeffrey Gritzner of the ACOS, and Robert Kates of Clark University has undertaken an analysis of weather/crop yield forecast models in relation to USAID's disaster-assistance efforts in the Sahel. The report which is to emerge from the analysis is scheduled for publication in May.

As indicated in our previous semi-annual management report, the ACOS had agreed to cooperate with Senegalese Délégation Générale à la Recherche Scientifique et Technique (DGRST), presently the Secrétariat d'Etat à la Recherche Scientifique et Technique (SERT), in the analysis of Senegal's future health and energy requirements. As described in Appendix III (pp. 4-5), these activities were postponed indefinitely.

PROPOSED ACTIVITIES

ACTIVITY BLOCK I

Proposed Starting Date	Activities
4 Nov. 1979	(1) The Role of Trees in the Sahel (IDRC workshop; (Dakar, Senegal) BOSTID participation recommended by L. G. Lessard, IDRC's Associate Director of Forest Science.
5 Nov.	(2) CILSS Soil-Conservation Workshop (Dakar, Senegal) In response to a request by CILSS, BOSTID has agreed to prepare presentations dealing with (i) species selection, (ii) soil ecology in relation to revegetation, and (iii) rangeland seeding implements.
6 Nov.	(3) Soil Microflora Discussions (Dakar, Senegal) Proceeds from a BOSTID concern that the importance of soil microflorae, such as nitrogen-fixing Rhizobium, has been neglected in revegetation efforts in the Sahel. Exploratory discussions with USDA/Beltsville scientists and Sahelian foresters have encouraged efforts to establish a Rhizobium collection in the Sahel. NAS ref.: Microbial Processes (in press)
6 Nov.	(4) Crocodile-Management Discussions (Dakar, Senegal; Banjul, The Gambia) Consistent with our operational guidelines, the Presidential memerandum of 8/2/79 to AID, and explicit IUCN and CILSS priorities, BOSTID is very much aware of the neglected importance of wildlife in environmental planning. In response to interest expressed by the Senegalese Ministry of Rural Development and by the Wildlife Conservation Department of the Republic of The Gambia, BOSTID proposes discussions concerning the Papua New Guinea approach to crocodile management. The approach is economically, sociologically, and environmentally sound and is supported by BOSTID, the U.S. Fish and Wildlife Service, and leading international conservation organizations.
7 Nov.	(5) Water-Buffalo Discussions (Banjul, The Gambia) The discussions emerge from a July 1978 request by President Jawara that BOSTID explore possibilitie leading to increased milk production in The Gambia. Our response is buttressed by a recent BOSTID sponsored workshop, "Teh Water Buffalo: Its Potential for Developing Countries,"

ACTIVITY BLOCK I

held 16-18 July 1979 at Gainesville, Florida. It is tentatively proposed that an experimental herd be established in The Gambia and that a control herd be established elsewhere in the Sahel beyond the zone of trypanosomiasis.

9 Nov. (6) Mauritania Follow-Up Discussions (Nouakchott, Mauritani
Follow-up discussions related to BOSTID activities in agro-forestry and environmental management in Mauritania.

12 Nov. (7) Sahel Institute Environmental Planning (Bamako, Mali)
At the request of the Institute, BOSTID has agreed to assist with the elaboration of an Institute program in environment/ecology. It is proposed that this planning activity lead to an environmental conference tentatively scheduled to be held at Niamey in early 1980.

19 Nov. Joint BOSTID-IDRC Meeting (Ottawa, Canada)
Based upon a commonality of concern and approach, BOSTID and IDRC officers have agreed to explore areas of potential cooperation in the Sahel.

7 Dec. Meeting of the Advisory Committee on the Sahel (Washington, D.C.)

January 1980 Issuance of Mauritania Environmental Workshop Report (with species survey)

ACTIVITY BLOCK II

28 Jan. (1) Water-Buffalo Workshop (Banjul, The Gambia)

31 Jan. (2) Spirulina-Development Working Discussions (Niamey, Nige
Spirulina is a filamentous blue-green alga. Its rapid increas (12 g/m^2 per day under Sahelian conditions), high protein percentage (72% dry weight ease of recovery, and demonstrated social acceptance encourage further development. NAS ref.: Underexploited Tropical Plants with Promising Econo Value (1978 revised), pp. 162-168.

4 Feb. (3) Sahel Institute Environmental Conference (Niamey, Niger

11 Feb. (4) Arid-Zone Wildlife Management Discussion (Ouagadougou, Upper Volta)
Because wild species occupy distinct and usually complementary ecological niches, the standing biomas of wild species characteristically exceed that of domesticated livestock subject to the same conditio

In addition to the greater carrying capacity for wildlife, wild ungulates are more efficient in their use of water, are more tolerant of heat stress and disease, and therefore represent an important potential source of food in regions susceptible to drought.

April 1980 — Crocodile-Management Workshop (Zguinchor, Senegal)

June 1980 — Arid-Zone Wildlife Management Workshop (Ouagadougou, Upper Volta)

June 1980 — Issuance of Crop Yield Forecast Models Report

This report emerges from a study undertaken by Francis Bretherton (NCAR), Jeffrey Gritzner (BOSTID), and Robert Kates (Clark University) as a joint effort by the Academy's Advisory Committee on the Sahel and Climate Research Board. The report is written in support of AID's disaster relief activitie NAS ref.: Memorandum to Thomas Greathouse, AID, 10 July 1979.

June 1980 — Agro-Forestry Workshop (Ouagadougou, Upper Volta)

The workshop is proposed in order to focus a growing, but somewhat diffuse, interest in agro-forestry upon the development problems of the Sahel.

July 1980 — Panel on the Bioclimatic Evolution of the West African Holocene (Chicago, Illinois)

Environmental reconstruction implies an understanding of the evolution of environmental systems. Despite the efforts of atmospheric scientists, relatively little is understood regarding the relationship of evolutionary trends in the Sahel in relation to development activities.

July 1980 — Conference on the Social and Environmental Implications of Development Activities in the Sahel (Bamako, Mali)

The conference would deal analytically with the impacts of existing projects and with the probable impacts of propsoed projects. Analogue information would be drawn from arid and semi-arid regions beyond the Sahel.

APPENDIX I

STAFF SUMMARY REPORT:

AN ASSESSMENT OF AGRO-FORESTRY POTENTIAL WITHIN THE ENVIRONMENTAL FRAMEWORK OF MAURITANIA

Report of Working Discussions among Officials of

The Government of the Islamic Republic of Mauritania

the United States' Agency for International Development,

and a Panel of Scientists Convened by the National Academy of Sciences

Nouakchott, Mauritania

23-28 April 1979

Advisory Committee on the Sahel
Board on Science and Technology for International Development
Commission on International Relations
National Academy of Sciences-National Research Council

NATIONAL ACADEMY OF SCIENCES

Washington, D.C. 1979

This is a staff-prepared summary of discussions held in Mauritania, April 23-28, 1979, under the auspices of the Advisory Committee on the Sahel, Board on Science and Technology for International Development, Commission on International Relations, National Academy of Sciences-National Research Council. Funding for this activity was provided by the Sahel Development Program, Office of Sahel and Francophone West African Affairs, Bureau for Africa, Agency for International Development, under Contract AID/afr-C-1354.

CONTENTS

CHAPTER I

INTRODUCTION

The proposal for discussions between U.S. scientists and Mauritanian officials dealing with reforestation and the long-term environmental stability of Mauritania grew out of meetings among Robert Klein, USAID Mission Director in Mauritania, and staff members of the Academy's Board on Science and Technology for International Development (BOSTID). In these discussions it was noted that

o BOSTID's Advisory Committee on the Sahel (ACOS) has recommended that emphasis be given to reforestation and agro-forestry, which are basic to long-term environmental stability and a more productive ecological equilibrium throughout the Sahel region; and

o Mauritanian government officials need to be involved in a more active consideration of the environmental consequences of drought and deforestation, phenomena which display alarming--and potentially irreversible--ecological deterioration.

As a result, a joint NAS-Mauritanian environmental conference was tentatively scheduled for July 1979.

In connection with a proposed workshop on species selection for agro-forestry in the Sahel, which was to be held at Dakar, Senegal, in April 1979, an ACOS panel of forestry experts and specialists in arid-zone crops and browse shrubs was selected. When arrangements for the workshop were postponed at the request of the Senegalese hosts, alternative arrangements were quickly made to take the panel (Appendix I) to Mauritania.

The group visited Mauritania from April 13 to 28, 1979, and met on three occasions with officials of the Ministry of Rural Development, responsible for the protection of the environment (including forestry), agriculture, and livestock. The USAID Mission and the Mauritanian government (GIRM) arranged for members of the NAS panel to visit areas representing the six major ecological zones of the country, where discussions were held with local officials. On the basis of these visits, the panel prepared an outline of recommendations for activities to stimulate afforestation, reforestation, and agro-forestry in each of the regions. They presented their recommendations (Appendix II) to subsequent meetings of GIRM officials and the USAID Mission staff. An expanded version of the recommendations, including more detailed information on plant species of potential economic and ecological importance to Mauritania and other Sahelian countries, will be published in late 1979.

CHAPTER II

ENVIRONMENTAL PROBLEMS

Mauritania's population is predominantly engaged in agriculture and herding. The prolonged drought of the late 1960s and early 1970s and the lower-than-average rainfall during the past three years have promoted a series of environmental changes. These would include deforestation, widespread rilling and deflation, and the encroachment of dunes upon highways and settlements. As a result, inhabitants of traditional farming and grazing areas have moved with their animals into other areas or into settlement camps attached to urban centers. It has become evident that some of the measures undertaken to counter the effects of inadequate rainfall will themselves lead to further, and relatively unpredictable, environmental changes. For example, within the Chemama region, the closing of the Manantali and Diama dams in the mid-1980s will almost certainly have a profound impact upon Mauritania's future environmental status. As would be expected, the implications of environmental deterioration differ from region to region, leading to differing conclusions regarding appropriate ameliorative activities for each ecological zone. While the environmental problems observed by the NAS panel are common in one form or another to all of the countries of the Sahel, it must be emphasized that they appear in their most extreme and potentially irreversible forms in Mauritania.

A discussion follows of the six ecological zones visited:

The Chemama

The area along the northern bank of the Senegal River is the most heavily exploited for agricultural production, including irrigated rice farming, and the most thickly forested. In this area, large stands of gonakier trees (Acacia scorpioides var. nilotica) are directly supported by the annual inundation of the river. These forests are a source of firewood for the local inhabitants and are a source for charcoal for urban centers, particularly for Nouakchott, to which an estimated daily average of sixty tons is transported. As a result, large numbers of these trees have been felled, and charcoal operations are progressively shifting eastward along the river toward Bogné, some 200 kilometers from Rosso. In recent years, rainfall in the area (and presumably also in the Fouta Djallon) has been sporadic and subnormal and there has been little flooding of the Senegal River. (In years of heavier rainfall, the flood reaches almost to Nouakchott through an extensive depression, the

Aftout As-Saheli.) The limited flooding has resulted in the death of large numbers of the gonakier trees and has severely affected natural regeneration. Interestingly, in some areas, particularly near Rosso, the forests have been conscientiously protected (forêts classées) by the Service des Eaux et Forêts and have remained in relatively stable condition, despite the recent climatic adversities. However, these protected areas are limited when compared with the overall area being exploited. Furthermore, with the control of the annual flooding by the two new dams scheduled for completion in 1983-84, a substantial area of the gonakier will be doomed either by the absence of the flood water they require or as a result of inundation by the newly created reservoirs. This area is estimated to be between 20,000 and 28,000 hectares, perhaps one-quarter to one-third of the existing gonakier forests. Local officals of the Service des Eaux et Forêts estimate that, if present rates of exploitation continue, along with the loss of the doomed trees, the area will be completely denuded of trees within six to eight years. Large stretches of land are already bare except for occasional stumps, and erosion is occurring on an increasing scale. The contrast with the protected southern (Senegalese) flood plain of the river is striking. The implications of this for the adjacent areas--the dryland farming and pastoral zones that are already much more sparsely wooded--are equally serious, since it is likely that charcoal will be sought over an ever-expanding area. The stability of the present farming and herding system will suffer if the sparse tree cover that is now available is exploited. The ultimate fate of the area would be complete removal of the ground cover, as has happened, for example, in the Arabian peninsula.

The NAS panelists and Mauritanian and USAID officials agree that the problem has already reached a stage where--unless prompt action is taken--there are likely to be irreversible consequences for the Mauritanian environment, particularly in the area that is most critical for satisfying the future agricultural and energy requirements of the country. Unless reforestation and afforestation can be initiated immediately on a scale that will begin to match, and perhaps exceed, the rate of exploitation, the present level of productivity of the country is in jeopardy.

The proposed reforestation and afforestation programs have three elements: extension of the existing forêt classée protection; establishment of intensive fuelwood plantations composed of fast-growing species, to be planted were the land along the river is not to be used for irrigated food-crop production; and extensive replacement of the gonakier forest by other species that do not require annual flooding.

With regard to the final proposal, 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 is therefore proposed that, in addition to the conventional nursery arrangements--which need to be supported and strengthened--the exceptional circumstances warrant an experimental "shotgun" approach. This approach would involve the identification of experimental areas (perhaps ten 100-hectare plots) over which seed from a wide

variety of indigenous and exotic species would be applied by various broadcast techniques, including aerial seeding where appropriate. The areas would then be checked over the next two to three rainy seasons to identify those species that can be most successfully propagated by these methods. The result of this experiment would determine the extent to which much larger areas could be revegetated by the various techniques employed.

Clearly, even if these approaches work, they are likely to go only towards supplying present energy demands, providing neither additional resources for future growth, nor an environmental buffer against a further succession of poor rainy seasons. All possible measures should be taken, therefore, to further conserve firewood and charcoal through the introduction of more efficient kilns and stoves. Although solar devices are unlikely to make a major contribution to the energy economy of Mauritania in the near future, they, too, should nevertheless be tried; any economy in the use of wood is to be encouraged.

It might be added that Mauritanian officials have observed an abrupt decline in the fish production of the marigot within the riverine zone. This circumstance is accompanied by a corresponding decline in protein availability within the zone. The problem will be locally intensified as the OMVS dams are closed and the marigots are no longer nourished by the seasonal flooding of the river. Hence, development within the riverine zone might profitably include freshwater fish culture and management.

Region of the Oases

Of the ecological zones visited, the region of the oases has perhaps shown the least deterioration. This is because the effective ecological determinant of the region, available ground water, has apparently remained relatively unaffected by recent events.

Nevertheless, there are opportunities for improving the management of the oases in order to promote greater productivity and reinforce the environmental stability of their surroundings. Water-resource management is a prerequisite, with the application of both ancient and modern technologies to increase productivity. The use of improved shadufs, as well as windmills or animal-powered pump systems, for example, could provide a greater, continuous flow of well-water, where that is feasible and appropriate.

There are a number of agricultural techniques that could promote more effective use of the limited water resources, such as trickle irrigation, the use of ground-cover crops, mulching, and the use of better adapted varieties of crops, including those selected for heat tolerance. It should also be possible to reduce evaporation by establishing windbreaks, which, in addition to controlling water loss, could serve as sources of fuel and as animal-fodder reserves if multiple-use species (such as Prosopis glandulosa) are employed. To the extent that the oases can support greater numbers of people and animals (and there is evidence that nomadic pastoralists have been settling in numbers around the oases) this will tend to reduce the pressure on the drier rangelands.

The Pastoral Zone (approximately 200-400 mm rainfall)

The pastoral zone sustains most of the nomadic herders during the period they remain in Mauritania, approximately four to six months after the rainy season. It is sparsely vegetated, mainly with perennial grasses and infrequent acacias and balanites. However, millet and sorghum are grown in catchment areas behind earthen dams that impound runoff water for seasonal cropping. Improvement of the area is likely to be difficult because existing water-management techniques are about as sophisticated as can be expected for the resources available.

The herders should be approached sensitively to gain an understanding of their aspirations and perceptions. A knowledge of how and why they move their animals during their months in Mauritania will be necessary in developing an integrated system of management that will enable their needs to be met while permitting natural regeneration of the vegetation. In addition, some new varieties of forage and food crops could be introduced--for example, improved Acacia senegal, browse legumes, cucurbits, and drought-tolerant, short-season crops.

The Rain-fed Cropping Zone (over 400 mm rainfall)

This zone with a rainfall of more than 400 mm, supports a large number of settled farmers, who grow rain-fed millet and sorghum. It suffers from declining soil fertility, the destruction of soil cover and resultant erosion, and a reduction in the number of trees available for firewood and charcoal. The area is likely to be increasingly threatened as the riverine zone offers diminishing reserves of trees for energy supplies. However, there are possibilities for improving the situation through the application of agro-forestry techniques and the development of family and/or community tree plantations, with seeds or seedlings supplied to all interested parties, along with extension and other services. Improved varieties of crops can also be introduced. Further, the soil may need to be checked to ensure that critical soil factors are not lacking, such as mycorrhizal fungi for certain trees and Rhizobia spp. for leguminous crops.

The Coastal Zone (less than 250 mm rainfall)

This zone embodies the most prominent features of desertification: extreme aridity, salinity, erosion, and mobile dunes. There is a particularly urgent need to direct attention toward the more active features. For example, the main road from Nouakchott to Rosso and Saint-Louis, the principal supply route for the capital, is being undercut by erosion and encroached upon by dunes. The road is also heavily travelled by pedestrians and animals. In the coastal zone (sensu lato), the introduction of salt- and aridity-tolerant species for dune stabilization and windbreaks, including Atriplex spp., Prosopis tamarugo (which also provides animal fodder), and Australian tamarisk, would be appropriate, but would require a system of management and protection.

It should be noted further that the Mauritanian littoral is extremely active. The undercutting of structures along the coast can be expected unless the longshore drift is locally intercepted by groins or other accommodations are made.

The Nouakchott Area (50-200 mm rainfall)

Although situated within the coastal zone, Nouakchott, with its substantial urban population and its encampments of settlers in the peri-urban fringe, is a special case. The city's growth has been so explosive that resources designed to support a population of 35,000 now serve an estimated 175,000 to 200,000 people. Nouakchott's water supply, drawn from an aquifer 70 kilometers from the city is believed to be capable of supporting the present rate of water use for anywhere from eight to fifty years. It would be desirable to investigate this more thoroughly. The growth of Nouakchott has also led to extensive excavations to obtain building materials. These excavations, and other physical disturbances associated with the city's recent growth, serve as sources of particulate matter for the dust- and sandstorms that afflict Nouakchott--storms that increasingly interfere with air and ground traffic to and from the city. The Lutheran World Federation greenbelt project has been designed to combat this problem. In the past two years, 385 hectares have been planted with Prosopis chilensis, with the expectation that after trees have become established, they will be sustained by seasonal rains and access to ground water via their lengthy taproots. Unfortunately, the recent light rains have delayed growth and the nursery techniques employed do not encourage tap-root development. Therefore, the trees continue to require weekly watering.

Because water for the greenbelt understandably has low priority vis-à-vis the needs of other consumers, the selection of more drought-resistant species, such as Prosopis tamarugo, Euphorbia, and Salicornia, and the more efficient use of water (for example, through trickle irrigation and the use of microcatchments) could enable existing resources to serve a greater area. Some of the pressure on the peri-urban vegetation imposed by browsing livestock might be relieved by the local production of Spirulina, a filamentous blue-green alga which is elsewhere utilized as livestock (particularly poultry) feed. It is also used as a protein-rich additive to human diets in Chad, Algeria, Mexico, and other countries.

In this region, there are opportunities for exploring additional new approaches because of the resources available in the capital city.

CHAPTER III

GENERAL CONCLUSIONS AND RECOMMENDATIONS

In addition to the suggestions in the discussion of the different ecological zones, there are general needs for infrastructure and resources that are common to all the problem areas. There is need to strengthen the Service of Eaux et Forêts, Agriculture, and Elevage with training, extension, and research capabilities, to support an integrated program of reforestation, afforestation, and agro-sylvo-pastoral production. The following steps are recommended:

o The selection and introduction of new species for fuelwood, construction, food, and fodder;

o Public education about the protection of trees, the establishment of family plantations, legislation that supports standing trees (as opposed to the present law, which encourages clearing), and the need to economize on wood and charcoal use; and

o Water-use improvement (at Nouakchott, in the oases, and in connection with irrigation along the river).

In view of the seriousness of the situation, resources must be made available for this purpose. All other development activities in the long run will depend on the success of this effort.

In particular, the panel suggested some immediate actions the Mauritanian Government should undertake with support from USAID. These include:

o Improvement of the facilities of the agricultural school at Kaédi to facilitate the planting and protection of the seeds that were brought to Mauritania by the NAS panelists, and the production and selection of seedlings for planting next year. Funds are also required for fencing, salaries for guardians, and minor technical inputs.

o Activation of the IDA-financed rural development extension center outside of Nouakchott, for the same general purposes as assistance to the greenbelt project. Minor capital expenditure is required to connect the station to water and electrical supplies and to secure and improve the access road. The Government of Mauritania has funds for staff and recurrent expenditures.

o The design and implementation of a program to enable the Service des Eaux et Forêts, Rosso, to reforest the area adjacent to the one that will be destroyed by the controlled flooding of the Senegal River by both conventional and broadcast methods. This will require limited funds for the purchase of seed for the establishment of additional nurseries, for technical support, and for supplementary running expenses for Eaux et Forêts.

It was also agreed that USAID and NAS will make arrangements for a long-term program of cooperative activities in Mauritania. This will enable panels of experts in the area of reforestation and agro-sylviculture (and others, to be decided later) to make periodic visits (perhaps twice annually, one during the dry season, one during the rainy season) to assist Mauritanian officials in the implementation of the reforestation and agro-sylvo-pastoral program.

A national environmental conference will be convened by the Ministry of Rural Development, in cooperation with other concerned ministries and with the participation of a small panel of NAS/BOSTID specialists. This conference, scheduled to be held at Nouakchott in September 1979, will be designed to raise the level of national awareness regarding the seriousness of the environmental situation. It is expected that this conference will lead to a national program to counter environmental deterioration.

APPENDIX I

ACADEMY PANEL FOR THE MAURITANIA WORKSHOP

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Academy Staff Members

1. Dr. Michael G. C. McDonald Dow

2. Mr. Jeffrey Allman Gritzner

Mauritania Itinerary

17 April 1979	Washington	
18	Nouakchott (via Dakar) Tiguent Rosso	Dow and Gritzner
19	Rosso Tekane Siginong Tegedi Sintiane Leboudou Dar al-Barka Return to Nouakchott	Dow and Gritzner
20-23	Nouakchott	
24	Nouakchott Kiffa N'Takat Djouk Djonaba Monguel Leqceiba Kaédi	Dow, Gorse, Gritzner, and Winterbottom
25	Kaédi Nouadhibou Nouakchott	Dow, Gorse, Gritzner, and Winterbottom
	Nouakchott Boutilimit Return to Nouakchott	Mergen, Nabhan, and Norton
26-27	Nouakchott	
28 April 1979	Nouakchott Tiguent Rosso Tekane Siginong Tegedi Return to Rosso and continuation overland to Dakar	Dow, Gritzner, Mergen, and Nabhan

APPENDIX II

SUMMARY OF PROBLEMS AND SUGGESTED SOLUTIONS

Zone	Problem or Opportunity	Existing Responses	Proposed Activity	Species Selection
1. Riverine	- Overexploitation for charcoal - Change in ecology because of dams	- Protection	- Better use of firewood and charcoal - Afforestation a) Irrigated for charcoal and construction b) To replace gumakier i) aerial seeding ii) trial plots	- a) Eucalyptus etc. - b) Mixed tree crops
2. Ouaso	- Water management - Crop selection - Windbreaks and live fencing - Pest and disease control	- Extension of seeds, pesticides, fertilizer, and tools	- More effective water use (including dry farming) - Species enrichment and selection (heat tolerant and disease resistant)	- Various vegetables and fruits (dates, citrus, guava carrot, cucurbits etc.) - Prosopis juliflora, pomegranate etc. Ziziphus, Acacia spp.
3. Pastoral	- Range improvement - Watershed management - Dune stabilization	- Earthen dams - Livestock station (Bouakchott)	- Work with pastoralists to understand and meet needs - Controlled grazing and natural regeneration - Varietal testing in collaboration with IISA, ICRISAT, IMAT, IEMVT, ICRAF, CTFT, ORSTOM, IDRC, FAO etc.	- Tepary beans etc. Gum arabic, Balanites - Millet, Sorghum - Cowpeas/Legumes - Cucurbits - Browse shrubs
4. Rain-fed	- Declining fertility - Loss of cover, erosion	- Tree distribution	- Family tree plantations, village wood lots, and shade - Varietal selection	- Neem, Prosopis, fruit tree - Short season millet - Legumes and Rhizobia - Cucurbits
5. Coastal Zone	- Salinity, aridity, erosion, sand dunes	- FAC study - USAID renewable resources project	- Dune stabilization Selection of drought and salt tolerant species - Protection of bottom lands (windbreaks) - Physical intervention	- Atriplex - Prosopis etc.
6. Bouakchott Area	- Loss of ground cover sandstorms, excavations, water management	- Greenbelt	- Dune stabilization - Greenbelt consolidation (trickle irrigation, barriers) improved nursery and plantation techniques species selection - Planting salttolerbes	- Prosopis spp. - Tephrosia - Salsolonia - Parkinsonia - Atriplex etc.

APPENDIX III

MAURITANIA

Maps

I. Climatic Patterns

II. Water Resources

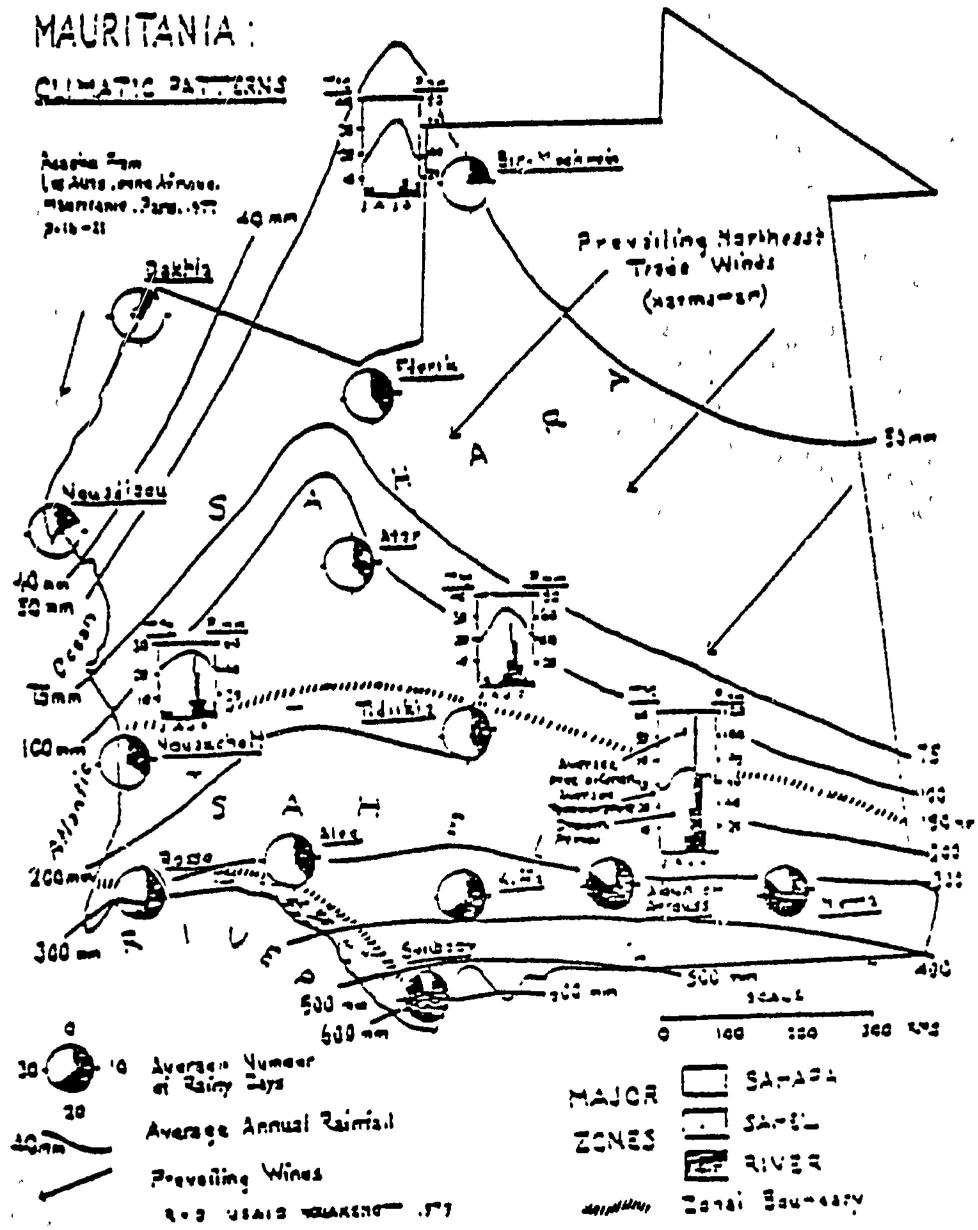
III. Desertification: Extent and Direction

IV. Nomadic Migrations

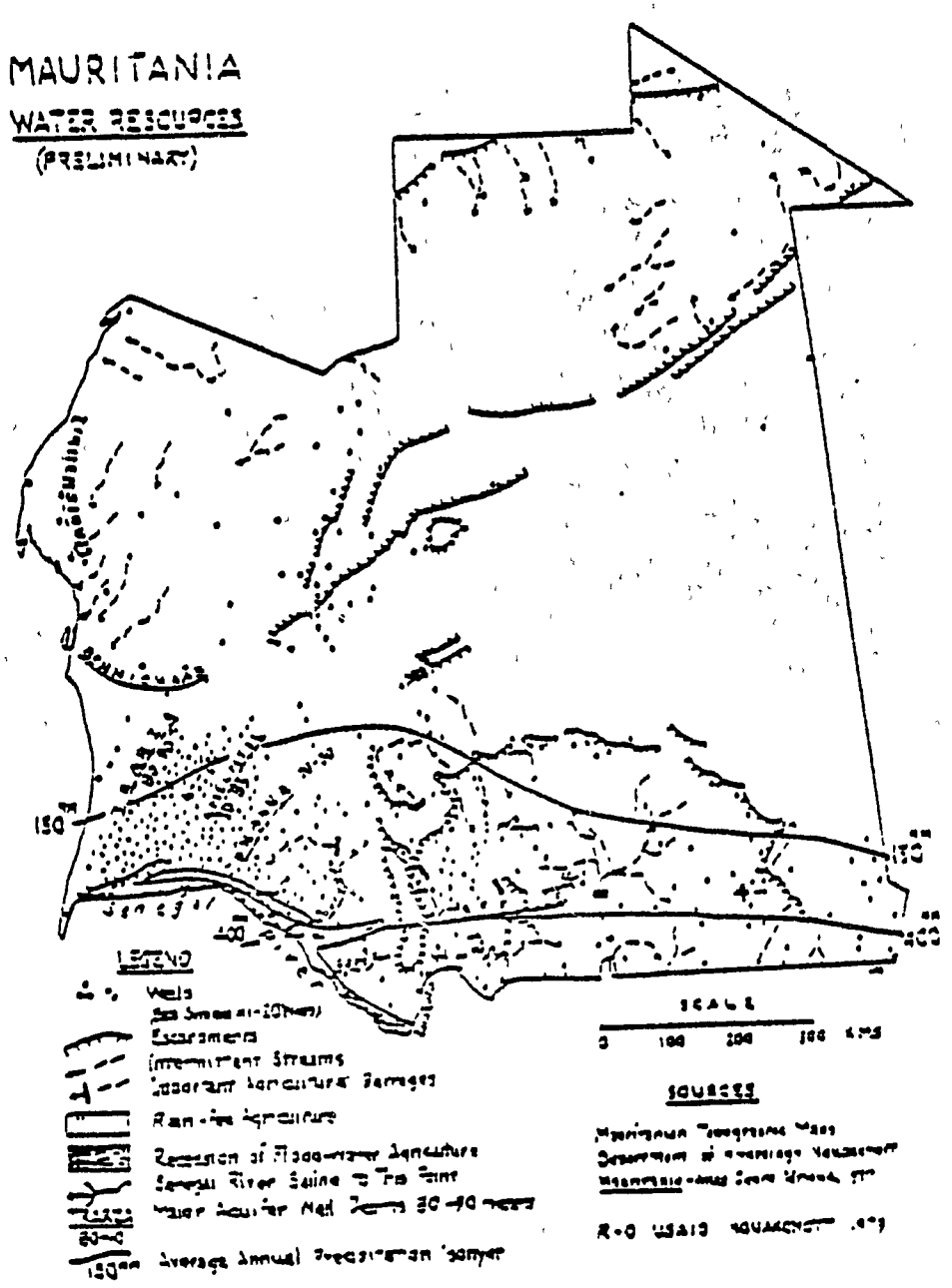
V. Urban Growth: 1961/1962-1977

Source: USAID/Nouakchott, 1979

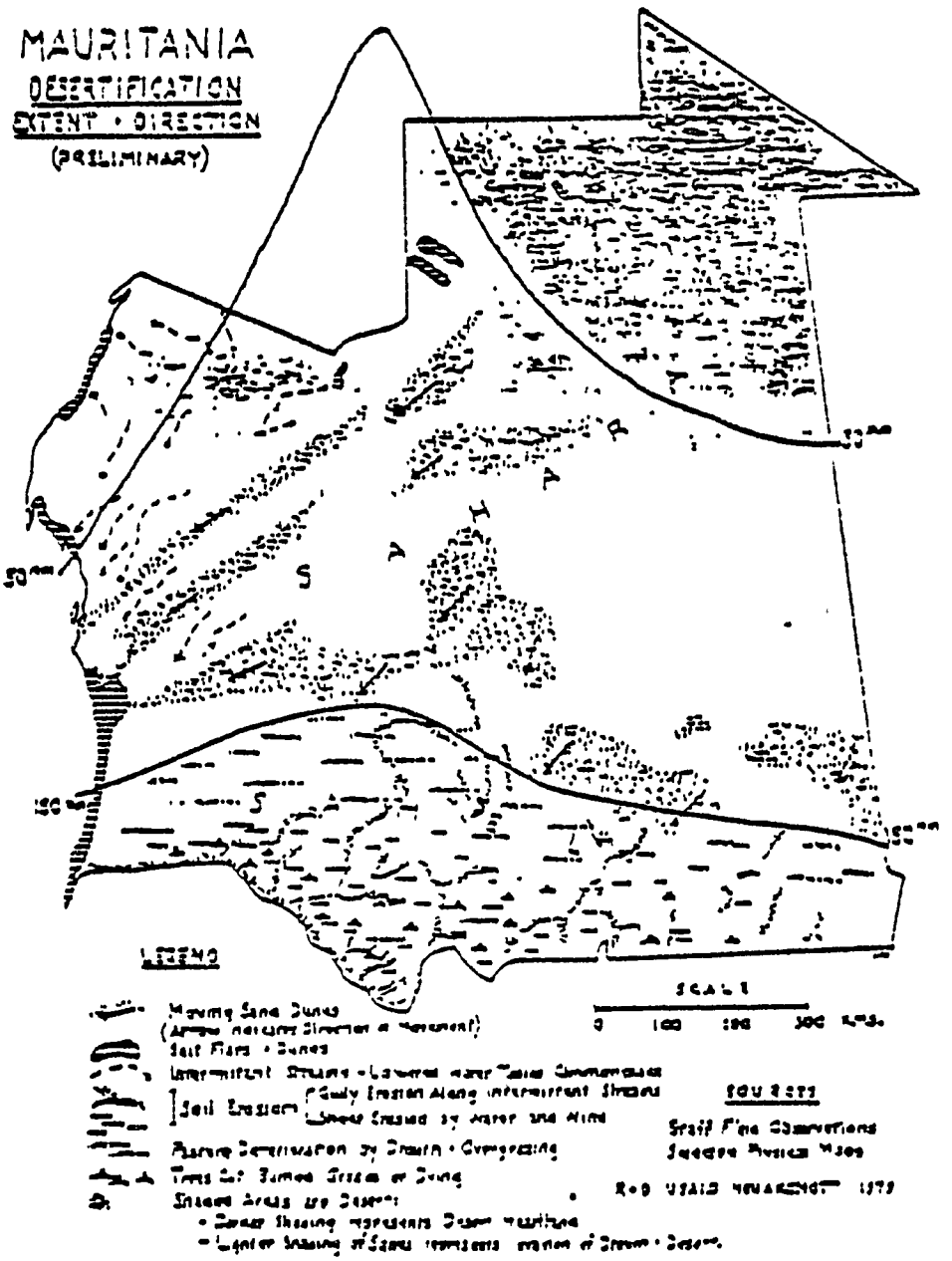
MAP I


MAURITANIA :
Prevailing Northeast Trade Winds
40 mm
Atar
Tidjikja
Nouakchott
Aleg
Average Annual Rainfall
Prevailing Winds
MAJOR ZONES
RIVER

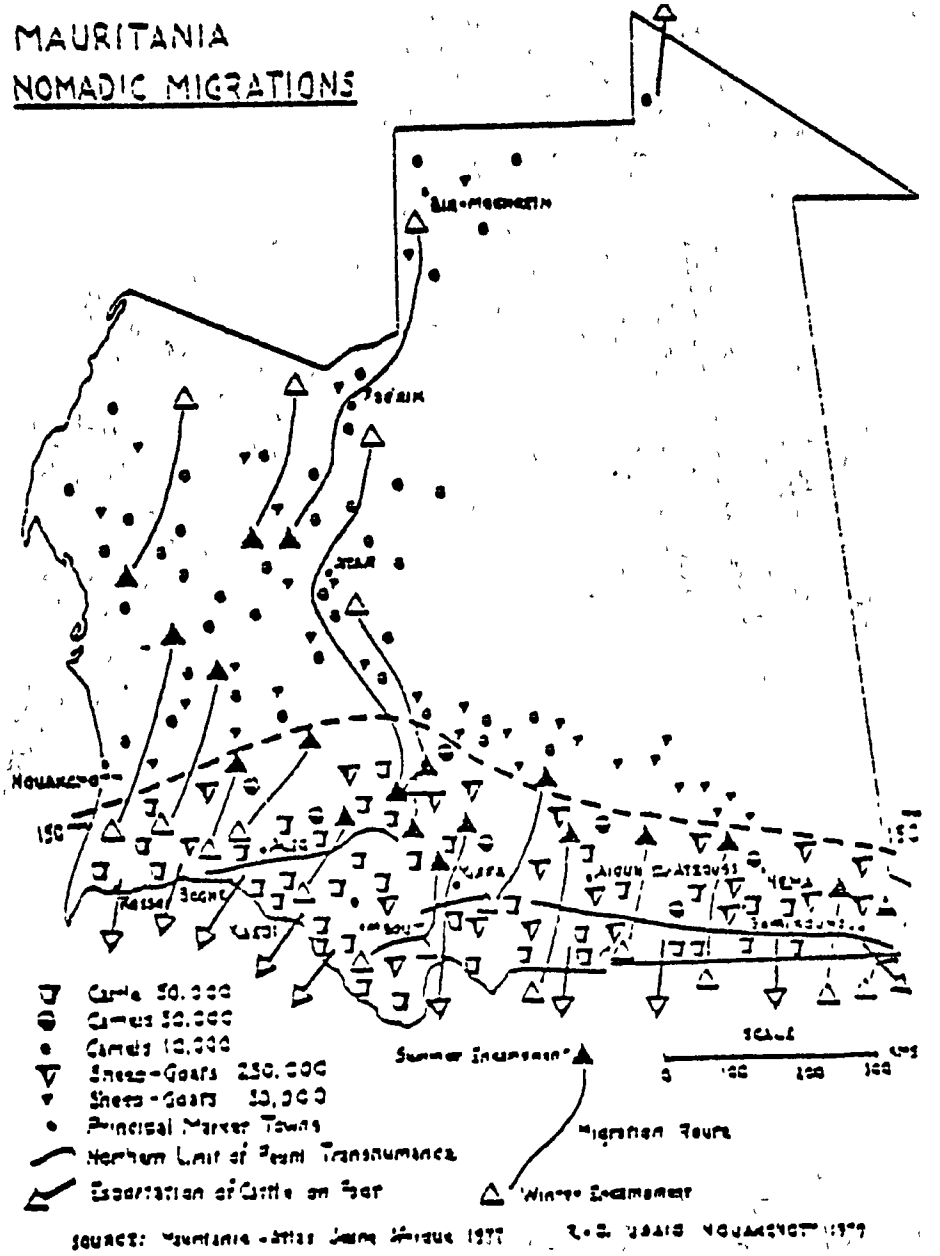
MAP II


MAURITANIA
WATER RESOURCES
(PRELIMINARY)
150
400
LEGEND
Wells
Escarpments
Intermittent Streams
Isocarm Agriculture Damages
Rain-fed Agriculture
Recession Flood-water Agriculture
Senegal River Saline to the Sea
Water Aquifer Mali
SCALE
0 100 200 300 KMS
SOURCES

MAP III


MAURITANIA
DESERTIFICATION
EXTENT • DIRECTION
(PRELIMINARY)
LEGEND
SCALE
0
100
200
300
Moving Sand Dunes
Salt Flats • Dunes
Soil Erosion
Gully Erosion Along Intermittent Streams
Sheet Erosion by Water and Wind
Planing Denudation by Drought • Overgrazing
Trees Cut Across Streams or Dunes
SOURCES
Staff Field Observations
Landsat Photos

MAP IV


MAURITANIA
NOMADIC MIGRATIONS
Cattle 50,000
Camels 50,000
Camels 10,000
Sheep-Goats 250,000
Sheep-Goats 50,000
Principal Market Towns
Northern Limit of Semi Transhumance
Concentration of Cattle on Foot
Summer Encampment
Migration Route
Winter Encampment
SCALE
0
100
200
300
SOURCE:

MAP V

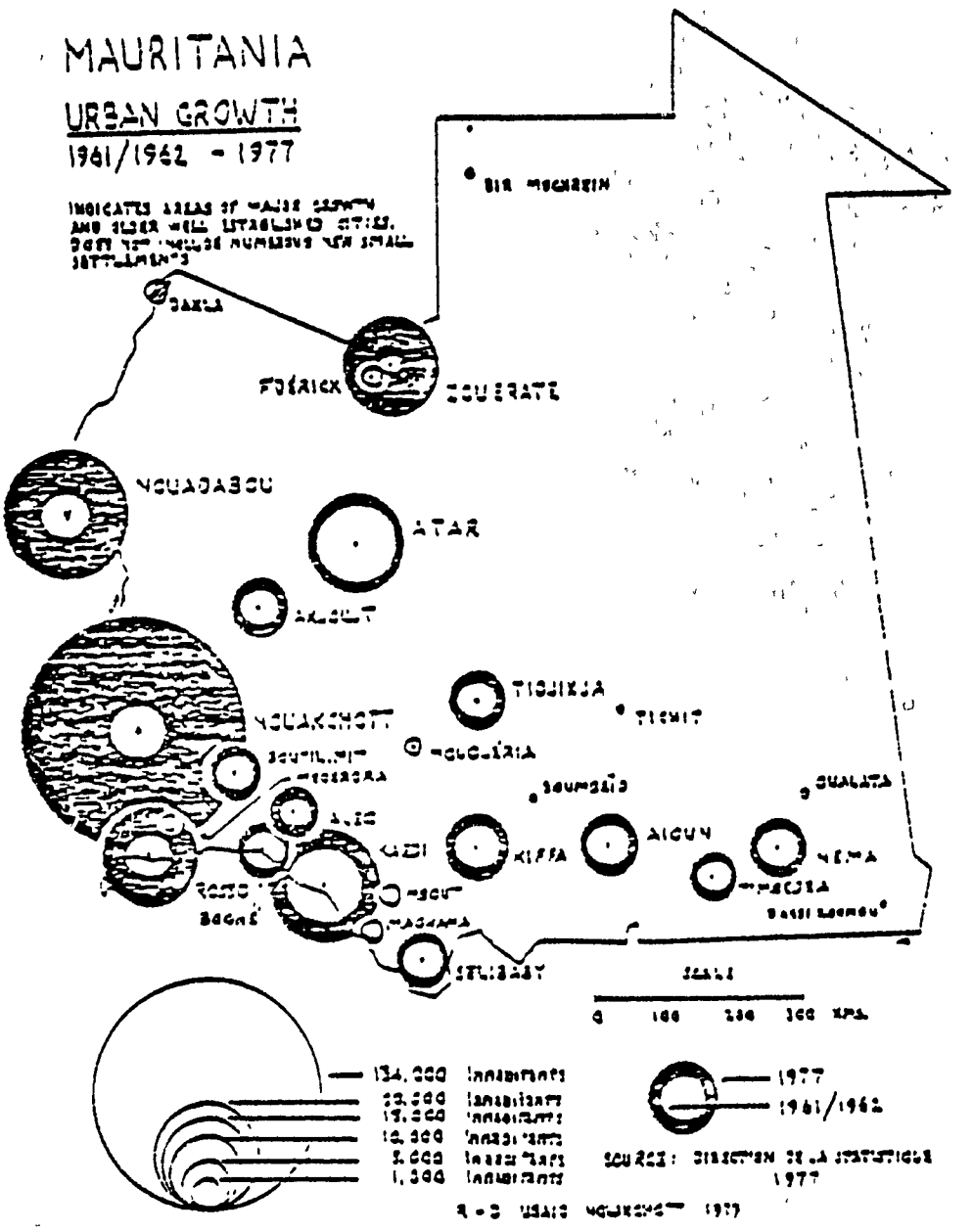

MAURITANIA
URBAN GROWTH
1961/1962 - 1977
INDICATES AREAS OF MAJOR GROWTH AND SOME WELL ESTABLISHED CITIES. DOTS OF VARIOUS NUMBERS ARE SMALL SETTLEMENTS
BIR MOGHREIN
ZOUERATE
NOUADHIBOU
ATAR
AKJOUT
NOUAKCHOTT
TIDJIKJA
TICHIT
OUALATA
KIFFA
AIOUN
NEMA
ROSSO
KAEDI
SELIBABY
1977
1961/1962
SOURCE: DIRECTION DE LA STATISTIQUE
1977

FIGURE 1 Riverine zone: Stumps of former gonakier forests, Leboudou, N. bank of River Senegal. The line of forest on the horizon is on the S. bank of the Senegal River.

Zone du fleuve: Souches d'anciens gonakiers, Leboudou, rive nord du fleuve Sénégal. A l'horizon, lisière du boisement situé sur la rive sud du fleuve Sénégal.

FIGURE 2 Charcoal-making, Bar el-Darka. Loading 10-ton truck.

Fabrique du charbon de bois, Bar el-Darka. Camion chargeant 10 tonnes.

FIGURE 3 Charcoal-making: Bar-el-Darka, N. bank of Senegal River.

Fabrique du charbon de bois: Bar-el-Darka, rive nord du fleuve Sénégal.

FIGURE 4 Riverine zone: Protected gonakier "old" forest (r); regenerated gonakier forest (l)

Zone du fleuve: boisement de gonakiers protégé (à droite); boisement de gonakiers régénéré (à gauche).

APPENDIX II

PRINCIPAL BOSTID VOLUMES DISTRIBUTED IN THE SAHEL IN CONNECTION WITH ACOS ACTIVITIES

Agriculture and Environment

1. Expansion des ressources en eau dans les zones arides: Techniques prometteuses et possibilities de recherches, 1977.
2. Guayule: An Alternative Source of Natural Rubber, 1977.
3. Leucaena: Promising Forage and Tree Crop for the Tropics, 1977.
4. Making Aquatic Weeds Useful: Some Perspectives for Developing Countries, 1976.
5. Perspectives de la recherche agronomique en Afrique, 1976.
6. Postharvest Food Losses of Major Crops in Developing Countries, 1978.
7. Products from Jojoba: A Promising New Crop for Arid Lands, 1975.
8. Tropical Legumes· A Resource for the Future, 1979.
9. Underexploited Tropical Plants with Promising Economic Value, 1975.
10. The Winged Bean: A High-Protein Crop for the Tropics, 1975.

Energy and Technology

11. L'energie et le developpement rural: Ressources renouvelable et et options techniques pour les pays en developpement, 1977.
12. Ferrocement: Applications in Developing Countries, 1973.
13. Methane Generation from Human, Animal, and Agricultural Wastes, 1977.
14. Resource Sensing from Space: Prospects for Developing Countries, 1977.

Note: Overseas program reports and other materials have been distributed as appropriate.

APPENDIX III

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

COMMISSION ON INTERNATIONAL RELATIONS
Cable Address: NARECO
Telex [illegible]

BOARD ON SCIENCE AND TECHNOLOGY FOR INTERNATIONAL DEVELOPMENT

TRIP REPORT

TRAVEL TO: Senegal and Mali, 28 April - 04 May 1979

BY: Dr. François Mergen, School of Forestry and Environment, Yale University, New Haven, Connecticut.
Mr. Gary P. Nabhan, Plant Science Department, The University of Arizona, Tucson, Arizona.

Dr. M.G.C. McDonald Dow, Deputy Director, BOSTID
Mr. Jeffrey A. Gritzner, BOSTID

FUNDING: Contract AID/afr-C-1354.

ITINERARY

28 April 1979	Mauritania:	Nouakchott Tiguent Rosso Tekane Siginong Tegedi Return to Rosso	Dow, Gritzner, Mergen, and Nabhan
	Senegal:	Ross-Bethio Saint-Louis Rao M-pal Saka Louga Gueoul Kébémer Ndandé Mékhé Pire-Goureye Tivaouane Thiès Rufisque Dakar	
29		Dakar	Dow and Gritzner
30		Dakar	
1 May		Dakar	
2	Mali:	Dakar Yof Senou Bamako	
3	Liberia: Senegal:	Bamako Senou Roberts Field Yof	
4		Washington, D.C. (via New York City)	

The principal objective of our trip was to participate in an evaluation of Mauritanian environmental conditions, particularly in relation to the effects of increasing fuelwood demands and possibilities for the enhancement of existing agro-sylvo-pastoral systems. Our observations and recommendations are contained in a companion report entitled: "An Assessment of Agro-Forestry Potential within the Environmental Framework of Mauritania: Staff Summary Report of Working Discussions among officials of the Government of the Islamic Republic of Mauritania, the United States Agency for International Development, and a panel of scientists convened by the National Academy of Sciences, Nouakchott, Mauritania, 23-28 April 1979." The present report briefly describes the continuation of our trip through Senegal to Mali for discussions with the directorate of the Sahel Institute.

Upon the completion of our working discussions in Mauritania, we travelled overland from Nouakchott to Dakar, Senegal. Within Mauritania, the landscape was only slightly differentiated. To the south of Nouakchott, we first passed through the northern extent of the Aftout as-Saheli, an extensive, linear clay depression bound in the west by shore dunes and in the east by immobile dunes (sbars) and active dunes. In some instances, it appeared that formerly immobile dunes were being reactivated through physical disturbance (such as road building) and devegetation. Continuing southward, we left the Aftout as-Saheli and passed through the dunal zone along the eastern margin of the de- ession into the clayey plains of the Senegal river valley.

The most conspicuous plant species of the Mauritanian coastal zone are Acacia spp., Adansonia digitata, Balanites aegyptiaca, Calotropis procera, Chenopodium spp., Euphorbia balsamifera, Melia azedarach (in association with permanent settlements), Parkinsonia aculeata, Salicornia spp., Salvadora persica, and a shrubby Tamarix, as well as various sedges and rhizomatous grasses. The vegetative communities are clearly degraded, with composition apparently determined as much by the unpalatability of their constituent species as by environmental constraints. Composition is further influenced by certain peculiarities of the coastal zone--for example, by the mist and fog produced by the interplay of warm air masses and the cold Canary current. Hence, efforts to enrich the specific composition of the coastal zone might profitably draw from the resources of analogous coastal deserts, such as the Namib and Atacama. The remanent baobabs (Adansonia digitata) might be numbered among the distributional anomalies of the zone as, in West Africa, the species is generally associated with the northern extent of the tall-grass savannah.

One of the more noteworthy transitions within the Mauritanian coastal zone was that from the poorly integrated drainage systems of the Nouakchott area (represented by the many sebkhas and aftouts) to the open systems oriented toward the Senegal river to the south. The latter reflect the stabilizing influences of greater precipitation and attendant vegetative cover. As this cover is removed through drought and careless management, however, the areas with well developed drainage systems become particularly susceptible to erosion. It would follow that efforts in revegetation should perhaps be initially focussed upon these latter areas.

We encountered few pastoralists and relatively little livestock in Mauritania. Most of the cattle had been driven southward into Senegal, and the small herds visible along the road were composed of goats, asses, and camels. Also along the road were traditional agricultural enclosures of living Euphorbia and acacia thorn. We were told that before the drought of the late 1960s and early 1970s the enclosures were much more numerous and contributed significantly to environmental stability. At Rosso, we again met with forestry official Oumar Aw, and again visited extensive tracts along the right bank of the Senegal from which gonakier (Acacia scorpioides var. nilotica) forests have been cleared to provide charcoal for Nouakchott.

Upon entering the Oualo region of Senegal near Richard-Toll, we were particularly struck by the immediate proliferation of plant species. While the increase partially reflects the greater environmental diversity of the Oualo, it to a greater extent reflects differing patterns of usage and management. The contrast again underscored the seriousness of the environmental emergency in Mauritania.

The area around Saint-Louis was marked by numerous abandoned river channels (marigots), tidal marshes, and relic dunes. The fresh-water interdunal marshes (niayes) contrasted strikingly with the salt-encrusted sebkhas of Mauritania. With attention increasingly focussed upon the large-scale agricultural projects of the Senegal river valley and the Casamance, it is easy to underestimate the economic importance of the niayes. They variously support vegetable gardens, banana plantations, and other intensive agricultural undertakings.

We continued southward through the Cayor district of the Western plains. The landscape was gently undulating with fields of relic dunes and azonal soils derived from argillaceous sandstones said to date from

the Miocene and Pliocene epochs. The precipitation of the district is usually in the 250-400 mm range. Considering this modest range and the allegedly destructive agricultural practices of the Wolof, the district was strikingly more verdant than Mauritanian districts, such as the Gorgol, which receive as much or more precipitation.

Continuing southward through the Western plains to Thiès, there were constant reminders of the regional importance of the groundnut (storage and transport facilities, roadside vendors, etc.). Beyond Thiès, we passed through the dissected region associated with the Eocene Thiès scarp, stopping briefly to visit an Eucalyptus plantation in the Sebikotane district. Continuing westward through industrial Rufisque, we arrived at Dakar late in the evening.

While at Dakar, we met with Norman Schoonover and James Procopis of the USAID mission, Linda Neuhauser of USAID's Office of Sahel and Francophone West Africa Affairs, and with the Family Health Care consultants recruited by USAID to assist the Senegalese Délégation Générale à la Recherche Scientifique et Technique (DGRST) define health concerns in relation to the current and forthcoming national, four-year development plans.

The findings of the Family Health Care consultants, Norman McEvers, Eli Newberger, and Julia Terry, were to have been translated into policy by a joint DGRST-National Academy of Sciences panel meeting in late May. The NAS was to have been represented on the panel by Herbert J. Kayden of the New York University School of Medicine, Alexander Marshall McBean of The Johns Hopkins University School of Public Health and Hygiene, and Marianne N. Bloch of Harvard University. Unfortunately, the terms of reference for the Family Health Care consultants were unexpectedly altered by the DGRST and the health effort was postponed indefinitely.

A joint DGRST-NAS consideration of renewable-energy policy was similarly postponed. The postponement of the energy effort was particularly regrettable, as energy consultant Charles Steedman of the University of Michigan had already compiled the necessary background material and it was clear that the effort was timely and relevant. The NAS panelists were to have been Ron Alward of The National Center for Appropriate Technology, Philip F. Palmedo of the National Center for Analysis of Energy Systems of The Brookhaven National Laboratory, and, again, Marianne Bloch. Peter C. Bloch of The Fletcher School of Law and Diplomacy of Tufts University, a manpower specialist,was to have served both the health and energy panels as a resource person.

Also while at Dakar, discussions were held with Fred Weber of the Idaho-based Resource Development and Conservation Service regarding NAS activities and opportunities in the areas of reafforestation and agro-forestry.

From Dakar, we flew to Bamako to meet with Nalla Kane, the Director-General of the Sahel Institute. The meeting was called in response to a series of broadly phrased Institute cables requesting NAS assistance in defining the Institute's program in ecology/environment. Accompanied by Thomas Park, USAID/Bamako liaison to the Sahel Institute, we met with MM. Kane, Silla, and Konaté of the Institute. The meeting was most cordial and productive, and resulted in an agreement to convene an interdisciplinary body to help define the Institute's efforts in the area indicated (see the attached). It was tentatively agreed that the meeting would be held

during the week of June 25th, 1979. Further discussion dealt with a proposed NAS contribution to a CILSS soil-conservation workshop to be held in November 1979 in Senegal and Cape Verde. The proposed contribution would draw heavily from our recent efforts in Mauritania.

Upon the completion of our meetings at Bamako, we returned to Washington.

EXTRAIT DU DOCUMENT INTITULE:

" Informations sur la Mission multidisciplinaire et multilatérale d'élaboration du programme de Première Génération de l'Institut du SAHEL"

Ecologie-Environnement: le programme qui doit en être issu doit appréhender et approfondir la réflexion sur l'écologie et l'environnement en étudiant le problème de l'écologie d'une manière globale et non sectorielle et en termes de bilan (les consultants de ce programme doivent être pluridisciplinaires):

- forestier
- agronome
- vétérinaire
- sociologue
- écologiste
- géographe
- médecin
- aménagiste etc...

Ce programme doit voir au renforcement, au niveau des Etats-Membres du CILSS, des unités d'évaluation et de planification. Les consultants doivent avoir à l'esprit le programme régional pour la satisfaction des besoins en produits forestiers et de la lutte contre la désertification.

Le programme devrait comprendre des recherches sur:

- les espèces forestières à fonctions multiples,
- les brise-vent,
- l'optimisation de l'utilisation des ressources ligneuses.

Il devrait aussi faire l'inventaire des informations disponibles au niveau des institutions de recherche travaillant dans le Sahel ou dans les zones écologiques en s'appuyant sur les organismes spécialisés.

Compte tenu du rôle combien important de l'homme dans la transformation et l'amélioration de l'environnement, le programme devra aborder le problème de l'écologie sous son aspect social et humain. L étude du rôle de la femme dans la transformation de l'environnement doit être

Le programme insistera aussi sur la restauration et l'aménagement rationnel grâce à des projets de caractère intégré et à des impacts précis sur l'espace sahélien par:

- la protection et la restauration du couvert végétal;
- la réglementation de l'exploitation des potentialités;
- l'aménagement des réserves sylvo-pastorales et cynégétiques;
- la gestion des éco-systèmes par les populations qui y habitent.

En conclusion l'idée maîtresse du programme arrêté est la restauration et l'aménagement de l'environnement sahélien.

Les consultants appelés à l'élaborer devront tenir compte des recherches suivantes:

- les espèces forestières à fonctions multiples;
- les brise-vent;
- l'optimisation de l'utilisation des ressources ligneuses;
- l'inventaire des informations disponibles dans le Sahel et dans les zones écologiques comparables;
- le rôle de la femme dans la transformation de l'environnement;
- la protection et la restauration du couvert végétal;
- la réglementation de l'exploitation des potentialités;
- l'aménagement des réserves sylvo-pastorales et cynégétiques;
- la gestion des éco-systèmes par les populations qui y habitent.

APPENDIX IV

Excerpted from Noel Vietmeyer's 1979 Royal Society Address, Underexploited Village Resources:

Crocodiles

In Africa, South and Southeast Asia, Australia and South America, the populations of crocodiles, alligators and caimans are fast headed for extinction. In Papua New Guinea in the 1960s, the two native crocodile species were headed the same way. But not today. In the last five years, a remarkably innovative project in this, one of the newest and most underdeveloped nations, has caused a dramatic turnaround in the crocodile's drastic decline there. Though the P.N.G. story has not been told widely, it is one with immense implications for the survival of crocodilians elsewhere. It is also a demonstration of how resources can be managed to conserve a species, to minimize impact on a fragile environment and to provide wealth in remote villages in a developing country.

The P.N.G. program is based on an appreciation for crocodile biology. Each year, a female may lay between 30 and 70 eggs, but though most of them hatch, predators so relish the tender and remarkably vulnerable young hatchlings that almost none survive the 15 years needed to reach breeding size. In nature, then, there can at anytime be found a plethora of tiny crocodiles, but a paucity of breeders. Commercial hunting worsens the imbalance because hunters always seek the biggest specimens, irregardless of the resulting damage to the breeding population.

Recognizing that a ban on hunting would be largely unenforceable in remote areas (and grossly unpopular where man-eaters sometimes occur), the P.N.G. Government decided in 1970 to restructure the trade so that shooting breeders would lose its attraction and the profit would come from exploiting the hordes of tiny hatchlings that would result. This was done through a law banning the sale of large skins, supplemented by a stiff tariff on small skins.

Today, villagers in the steamy swamps of P.N.G. have tens of thousands of tiny crocodiles in their care. They raise them for a year or tow and can then sell them for up to £40 each. Crocodile farming has already become the main cash earner for the people there. I personally met a village leader in Wewak who had come to oversee shipment of £5,000 worth of skins headed to New York by airfreight.

The P.N.G. crocodile project is characterized by:

Good Science. Despite popular "man-eater" impressions, crocodiles live mainly on fish, though the researchers in P.N.G. have found that young ones also grow well on frogs, snails and beetles. The feeding efficiency is astounding: 1 1/2 kg of food gives 1 kg of weight gain, and hatchlings 30 cm long can grow to be almost 2 m long in less than 2 years. (Conventional domestic livestock require 5 to 8 kg of food to produce 1 kg of weight gain.) Crocodile farming is also space efficient: dozens of animals are raised in an area the size of one of our household living rooms; in a swamp or jungle that's important.

Good Conservation. Because the program is based on harvesting young hatchlings from the wild, the economic value of the wild populations and their habitats becomes forcefully apparent. The program's future depends on them. It gives economic value to wildlife protection. Out of pure self-interest, the people become guardians and conservers of habitats and wildlife. In a sense, the farming project is just a tool for conserving the species in its own wild habitat; that's why it is operated by the Wildlife Division of the P.N.G. Government.

Good Sociology. The villagers have a sophisticated knowledge of the crocodile; the animal is part of their culture and heritage. They don't have to be taught how or where to catch crocodiles, and they take quickly to the program. Introducing cattle or Western-style crop-raising would require massive and tedious education and training.

Good Environmental Management. The program is based on living with the existing landscape and resources. It requires none of the bush-clearing, fencing, forage-grass planting or pesticide spraying that rearing other domestic animals would demand. That's important in a fragile tropical rainforest ecosystem.

APPENDIX V

NATIONAL ACADEMY OF SCIENCES
NATIONAL RESEARCH COUNCIL
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COMMISSION ON INTERNATIONAL RELATIONS
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16-18 July 1979

The Water Buffalo: Its Potential for Developing Countries

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Study
~~Discussion Seminar~~ on ~~Using~~ Non-Conventional Techniques and Species for Land Reclamation

~~Seminar~~ Contributors

	Topic:
David Dawson Institute of Forest Genetics (715) 362-7474	Intensive culture of poplars.
Robert M. Dixon Southwest Rangeland Watershed Research Center (602) 792-6381	Revegetation of semiarid rangelands using rollers to imprint microcatchments in the soil.
Kenneth L. Giles Iowa State University (515) 294-3908	Tissue culture of poplar, aspen, acacia eucalyptus and other trees.
William T. Gladstone Weyerhaeuser Company (206) 924-6635	In vitro vegetation propagation techniques.
Fred F. Grau (301) 864-0090	Crownvetch.
Robert MacLauchlan Soil Conservation Service (202) 447-5667	Plant materials used by S.C.S.
William Mann Alexandria Forestry Center (318) 445-6511	Aerial seeding of 2 million acres of pine forests in the South.
Richard McCarthy Washington Irrigation & Development Corporation (206) 736-2831	Strip mine revegetation.
Cyrus McKell Institute of Land Rehabilitation (801) 752-4100 (ext. 7266)	Shrubs for revegetation in semi-arid lands.
Donald Plucknett Board on International Foreign Agricultural Development (202) 632-7938	Aerial seeding of watersheds in Hawaii.
Gerald Schuman High Plains Grassland Research Center (307) 778-2220	Soil reclamation species on the High Plains.

Noel Vietmeyer
National Academy of Sciences
(202) 389-6524

Tree legumes: shock troops for the war on deforestation.

Willis Vogel
U.S. Forest Service
(606) 986-8431

Direct seeding of strip mine spoil in Appalachia.

John Waldrum
Union Carbide Corporation
(215) 628-1497

Aerial seeding with a slurry of seed, fertilizer, growth hormone, inoculant and pest repellent.

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