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**Toward a National
Strategy for
Natural Resource
Management in
El Salvador:
A Concept Paper**

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**Toward a National Strategy
for Natural Resource Management
in El Salvador:
A Concept Paper**

by

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EXECUTIVE SUMMARY

El Salvador is the smallest and most densely populated country on the mainland of the Western Hemisphere. It has a long and unfortunate history of misuse of its environmental resources. This history long precedes the current civil conflict that has exacerbated the condition. National problems of environmental degradation and natural resource depletion are severe, and directly affect the economic and the quality of life of the majority of Salvadorians. The U.S. Agency for International Development is working with Salvadorian agencies to alleviate problems and to plan for the future. The design of a National Strategy for Natural Resource Management is one such effort.

The National Strategy must consider the gamut of environmental and natural resource problems in the country, including deforestation, soil erosion, loss of soil fertility, water supply, environmental contamination, pesticide abuse, loss of wildlife habitat, and data collection and environmental monitoring. The plan proposed to address these problems consists of a number of steps to be taken, some simultaneously, over a two-year period. These steps are: establish an office within the Fundación Ecológica Salvadoreña, a Presidential Commission on Natural Resources and Environment, a national technical team, and an external support team; install a geographic information system; create a national data directory, a centralized library, and an information bank; hold workshops on the information bank; define priority areas for action; design, implement, and evaluate initial projects; prepare an issues paper; hold national congresses on the strategy; define and implement subsequent projects; and elaborate the strategy.

This concept paper will serve as a valuable guide to both the El Salvador USAID Mission and the Government of El Salvador in developing long-range plans for the stabilization, regeneration, and management of El Salvador's dwindling natural resources.

EL SALVADOR and CENTRAL AMERICA



Approximate Scale 1 : 5,500,000

LIST OF ACRONYMS

ANDA	Asociación Nacional de Acueductos y Acantrillados (national water utility)
CEL	Comisión Ejecutiva Hidroeléctrica del Río Lempa (national power utility)
CENREN	Centro de Recursos Naturales
DEM	Digital elevation models
FES	Fundación Ecológica Salvadoreña
GIS	Geographic information system
IGN	Instituto Geográfico Nacional
IUCN	International Union for the Conservation of Natural and Natural Resources
MAG	Ministerio de Agricultura y Ganadería
NGO	Non-governmental organization
PVO	Private voluntary organization
RENARM	Regional Environmental and Natural Resources Management (A.I.D.)

This paper was prepared at the request of the U.S. Agency for International Development in El Salvador. The objective was to lay the groundwork for a detailed National Strategy on Natural Resource Management. It sets forth how a Strategy should be prepared, data and information requirements, the kinds of people and institutions necessary to complete it, and other factors that should be in place before success can be achieved.

THE ENVIRONMENT/NATURAL RESOURCES SITUATION

El Salvador is the smallest and most densely populated country on the mainland of the Western Hemisphere. The national territory is approximately 20,000 kilometers with an estimated population of over five million. El Salvador is characterized by most of the major socioeconomic indices of "underdevelopment": rapid population growth, a high percentage of population in rural areas, highly unequitable income distribution, and low standards of health, nutrition, sanitation, housing, employment, and education.

These socioeconomic conditions have been exacerbated by nearly a decade of civil conflict, with tragically high human costs. The war has also disrupted food production and marketing systems, wreaked economic havoc on physical infrastructure, and resulted in the diversion of vast sums of public funds to the war effort.

The overall impact of the war has been to place additional stress on an already inadequate system of social services and on the ability of the country to meet the basic human needs of the majority of its population. The military conflict has also had an important indirect ecological impact on the landscape and the people, largely through the displacement of large numbers of the rural population and the disruption of natural resource management programs.

Often overlooked, however, is the fact that El Salvador had a long and unfortunate history of environmental abuse and misuse of its natural resources well before the outbreak of the civil war. This environmental and resource degradation has been documented throughout most of this century (for example, Standley, 1924; Bourne, et al., 1946; Vogt, 1946). In the late 1970s, El Salvador was already the most ecologically degraded country in mainland Latin America (Daugherty et al., 1979). This degradation reduced the capability of the land to support its people and added to the sociopolitical tension and strife present in the country.

During the 1980s, El Salvador also had to cope with a devastating earthquake that hit San Salvador in October 1986. The monetary value of the damage surpassed 25 percent of the country's gross domestic product for that year.

The current problems of environmental degradation and natural resource depletion are severe on a national scale, have direct economic impacts, and seriously affect the quality of life of the majority of the Salvadorean people.

Government institutions are in disarray, and marked by overlapping jurisdictions, lack of funds, and flight of highly qualified personnel to the private sector. Furthermore, conservation and management of the natural resources on which the Salvadorian economy is based have been given an extremely low priority during this decade.

The environmental and natural resources legal framework is characterized by a diversity of discordant legislation, much of which is outdated and some of which is truly antiquated, rendering a substantial part of this legislation inapplicable or inappropriate for current and rapidly changing conditions. Furthermore, there is little effective enforcement of those existing laws that are clearly defined (for a detailed analysis, see Serrano, 1989).

There are critical problems with respect to data and information systems. Data collection and environmental monitoring have been seriously interrupted by the civil strife of the last decade. Large data gaps now exist and preclude time series analyses so important in forecasting and decision making.

In spite of the persistent political/military situation in El Salvador, a large number of projects and programs are underway in the country that have environmental or natural resource management components. These are being carried out by a host of national and international institutions (including USAID). However, most of the projects are isolated, and are being conducted without a common operational framework and, of course, without a cohesive national strategy that could integrate the various elements and activities.

The environmental and natural resources situation has been studied in considerable detail. Studies exist on deforestation, soil erosion, loss of soil fertility, water supply, environmental contamination, pesticide use, loss of wildlife habitat, and international trade in wildlife. Soil erosion and wildlife depletion, for example, have been studied since the 1920s (Standley, 1924).

Several integrated and interdisciplinary studies have also been done. The *Environmental Profile of El Salvador*, completed in 1985, is a good diagnosis of the state of the nation's natural resources in the early 1980s (Guevara, et al., 1985). A Central American profile was published by Leonard (1987). Several other USAID Mission reports and documents also summarize the major problems in natural resource conservation and management in El Salvador. The Regional Environmental and Natural Resources Management (RENARM) Annex for El Salvador (USAID/El Salvador, 1989a) is an excellent summary of resource problems on a national scale and clearly identifies the challenge ahead.

A National Conservation Strategy for Costa Rica is forthcoming, prepared under the auspices of the International Union for the Conservation of Nature and Natural Resources (IUCN) (Quesada, in press), which can serve in part as a model for the preparation of the national strategy for El Salvador. A Plan and Strategy for Protected Areas is being prepared by Servicio de Parques Nacionales y de Vida Silvestre of the Ministerio de Agricultura y Ganaderia (MAG) in El Salvador, with support from the IUCN. The Canadian International Development Agency's work in ecodevelopment in the late 1970s and 1980s laid a sound conceptual framework for natural resource management in El Salvador.

A preliminary outline of a potential strategy for natural resource management in El Salvador ("Estrategia Nacional de Manejo de Recursos Naturales y Recuperación del Medio Ambiente") has been prepared by the technical committee of the Fundación Ecológica Salvadoreña. The authors discussed this outline in detail with several members of the technical committee, meeting with them individually. They reached consensus with these members that the outline can serve as a basic starting point for defining the Strategy in detail.

CURRENT USAID/EL SALVADOR ACTIVITIES

USAID/El Salvador is contemplating action in the following areas related to natural resource management and environment:

1. Sustainable Agriculture

- fragile lands management
- improved pest management
- tree cropping
- public and private institution building
- agricultural extension in pesticide misuse

2. Production from Natural Forests

3. Management of Wildlands and Protection of Biological Diversity

- identification and management of threatened wildland areas
- protection of biodiversity and germplasm
- support for the Convention on International Trade in Endangered Species
- support for the Centro de Desarrollo Pesquero
- establishment of a national conservation data center
- management plans for protected areas, including buffer zones
- coastal resource management (aquaculture, protection of mangrove forests, estuary wildlife, and management of bordering agricultural lands)

4. Management and Rehabilitation of Critical Watersheds

- reforestation
- watershed management

5. Policy Formulation, Institutional Strengthening, and Environmental Education

- initial design of a National Natural Resources Management Strategy
- public and private institution building, with an important focus on nongovernmental (NGO) and private volunteer organizations (PVO)
- environmental education through NGOs, PVOs and public sector institutions as a major tool for institution strengthening (this is viewed by the Mission as "one of the initial priority roles," RENARM, Annex for El Salvador (USAID/El Salvador, 1989, p. 13).

It is within this context of ongoing USAID/El Salvador programs, projects, and priorities that this initial design for a National Strategy for Natural Resource Management is presented.

This proposed National Strategy also considers the framework of "AID Priority Areas" for reversing the trends toward environmental degradation that have the greatest impact on "the rural poor and the disadvantaged segments of society who most depend on natural resources" (USAID, 1988b, p. 17). The "strategic goal" of AID action is:

to produce, with the citizens of the Central American countries, the conditions for sustained exploitation of natural resources in a manner that minimizes the damage to the environment, protects biodiversity, and provides the means for equitable and sustainable economic growth (USAID, 1988b, p. 17).

OBJECTIVES FOR A PROPOSED NATIONAL STRATEGY

Objectives can be summarized as follows:

- (1) To initiate a comprehensive, cohesive, integrated policy and action plan at the national level that would address the environmental issues outlined above.
- (2) To integrate and unify USAID-Salvadorean Government policies, programs, and projects and those of other international donor agencies.
- (3) To catalyze efforts by the government and the private sector, NGOs, and PVOs, and the international community to reverse the trend toward resource degradation, declining economic viability, ecological instability, and environmental deterioration through a creative and unified plan of action.
- (4) To establish priority areas for immediate action based on existing knowledge and sound scientific evidence, and to initiate projects based on these priorities.
- (5) To define goals and targets for the short- and longer-term which would be implemented in distinct, but interrelated, phases.
- (6) To formulate a longer-term policy and implementation strategy that the government, through its own active participation in the process, can officially endorse and forcefully pursue and implement.
- (7) To provide a set of specific and detailed guidelines and a concrete plan of action for natural resource management by the Salvadorean government, USAID, and other international donor agencies.
- (8) To initiate the process of systematic data collection and analysis and monitoring of principal environmental parameters and indicators. This represents more than the reestablishment of the data collection network operating in 1980, which has been seriously disrupted; it means the establishment of criteria for uniform, standardized, and compatible data collection and analysis — criteria that have never existed in El Salvador.
- (9) To document that economic growth and stability, and a strong and vibrant private sector, are closely linked to resource management practices based on sound ecological and economic principles that address local human needs and aspirations. This understanding needs to be disseminated through a broadly based national program of environmental education.
- (10) To generate public awareness of the vital relationship between sound natural resource management and socioeconomic well-being. There is an increasing understanding of these

interrelationships in some sectors of Salvadorian society; the environmental education program to be elaborated in the Strategy could be the catalyst to mobilize this understanding into concrete actions throughout the society.

(11) To initiate the transition from short-term resource exploitation ("mixing of resources") to a longer-term and truly sustainable development process that meets the needs and aspirations of the majority of the population while ensuring the renewability of the natural resource base and the protection of biological and genetic diversity.

In summary, a national strategy would promote enlightened change to enhance economic productivity along with sustainable resource use, and would promote environmental restoration within a framework of socioeconomic justice and political harmony. It can contribute directly to the achievement of USAID policy for El Salvador, U.S. public policy in environmental management and natural resource use, and regional A.I.D. policy for the environment and natural resources in Central America.

A METHODOLOGY FOR FORMULATING A STRATEGY

The key elements necessary to formulate and implement a natural resource strategy consist of administrative, technical, and political components. In chronological order, they are as follows.

Establish an Office

A first priority is to establish a functioning office in the Fundación Ecológica Salvadoreña (FES) through provision of start-up funds and operating costs. This office would have two functions: (1) to conduct the day-to-day administrative affairs of the FES (fund raising, memberships, publicity, and so forth) and (2) to provide the focal point, physical infrastructure, and logistical support for the elaboration of the national Strategy.

FES is a young but dynamic, well-respected, and broadly based NGO. It has proved to be highly successful in fund raising and project implementation, primarily in the fields of health and rehabilitation of disadvantaged and disabled children. It has staged the most successful telethons in the history of the country. The Fundación was created through the Club Activo 20-30 of San Salvador, which was recently recognized internationally as the best club in the country.

FES would serve as an umbrella organization and would channel funds and resources to other, smaller environmental NGOs that require funding for specific projects. The Fundación would provide leadership and play a catalytic role for other NGOs; it would not implement projects on its own.

FES has a technical committee composed of many of the leading environmental scientists and professionals in the country, which would serve in an advisory capacity on project evaluation and implementation. FES also has the strong support of the private sector and the media.

Create a Commission¹

A second priority is the creation of an interinstitutional Presidential Commission on Natural Resources and the Environment to provide a catalytic leadership role at the highest governmental level for the preparation of the Strategy (Figure 1). The Commission would be composed of representatives from the public and private sectors, FES and other NGOs, the university community, trade unions, and cooperatives. The Commission would be directly responsible to the President of El Salvador.

This Commission would also serve as a catalyst to generate a broad base of support for the Strategy and the activities related to it, as well as give the Strategy official government validity, authority, credibility, and legitimacy. The Commission should indicate by official decree, with Presidential endorsement, its support for the entire implementation process of the National Strategy.

Apart from its normative role in the preparation of the Strategy, the Commission would have other functions, such as environmental mediation, risk assessment and litigation, resolution of land use and other resource conflicts, and would be the overseer of environmental protection and quality in general.

Establish a Technical Team

Another critical component of the Strategy is the establishment of a national technical team headed by a full-time national coordinator that would be responsible for the preparation of the Strategy. The national coordinator would have a direct international counterpart, and the technical team would be assisted by short-term external consultants when appropriate.

The national technical team would have core members with experience in policy formulation and program/project management. The team would be interdisciplinary, and would consist of environmental scientists and professionals from different fields, including environmental education, organizational/institutional management, law and the judicial system, hydrology, soils, land use, agriculture, forestry, agroforestry, national parks and wildlife, demography, and anthropology. Several members of the team would likely be drawn from the existing Technical Committee of the Fundación.

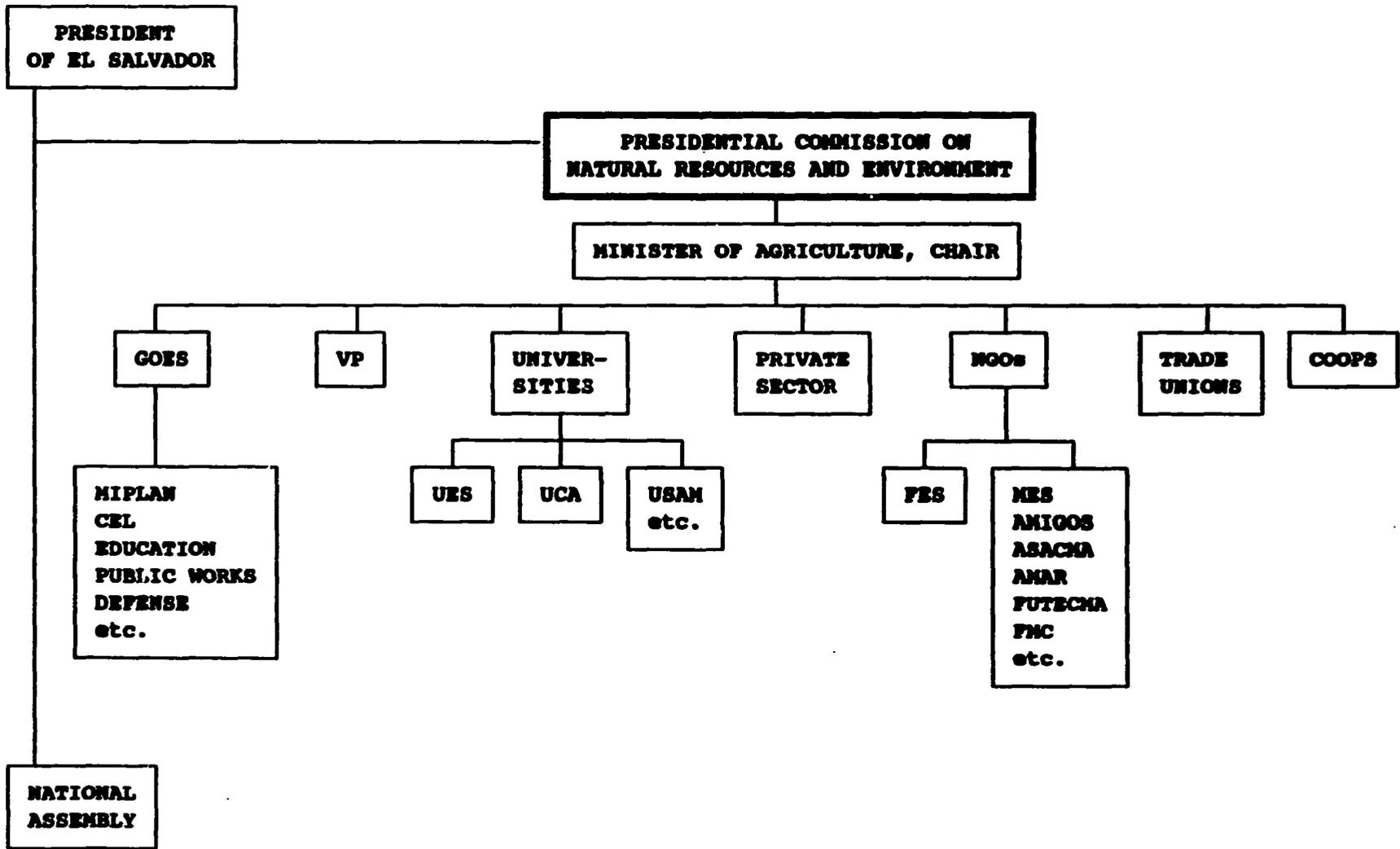
The external support team would be headed by a natural resource planning and management expert and supported by a core of specialists in the key areas of systems analysis, resource economics, NGO management, and environmental education. This core would be reinforced by shorter-term consultants in those fields where weaknesses are identified in the national team (most likely in organizational/institutional change and management, systems hydrology, environmental contamination, and geographic information system (GIS) management).

¹ An alternative method of preparing a Strategy would be to lessen the prominence of the Salvadorean government and pursue a more pluralistic approach by giving a greater role to the private sector.

FIGURE 1

ORGANIZATIONAL CHART

PRESIDENTIAL COMMISSION ON NATURAL RESOURCES AND ENVIRONMENT



The technical teams (national and external) would have complete autonomy and independence in their activities and functions (Figure 2). The substantive content of the Strategy would be the responsibility of the technical team, with the Presidential Commission serving in an advisory capacity. The Fundación and its membership would make its input into the Strategy along the same channels open to others.

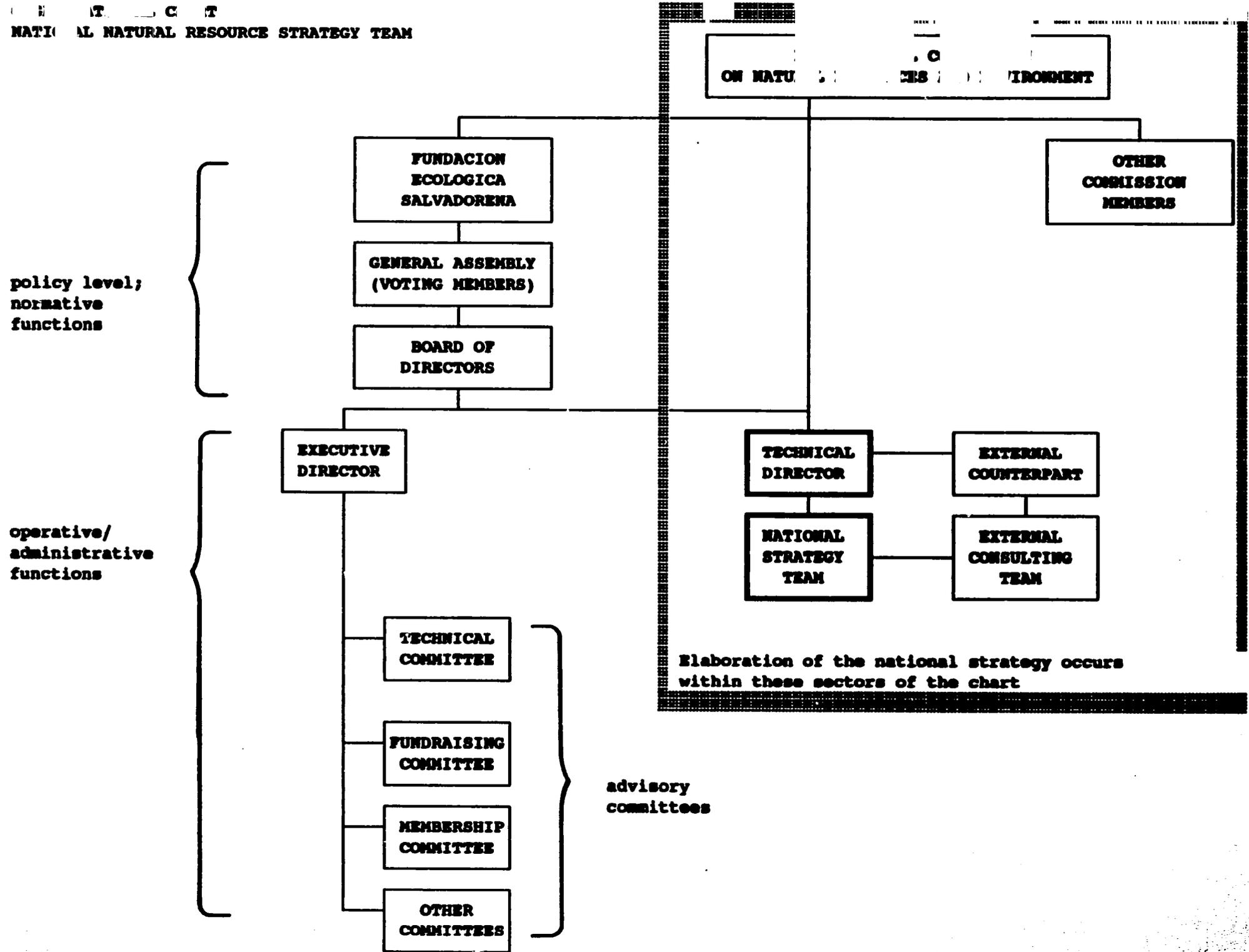
The national team and the external team will each represent approximately eight to ten person-years of effort to elaborate the Strategy over a two-year period and to formulate and launch the initial projects.

Technical Team Activities

Once constituted, the first task of the technical team would be to define in detail the outline for the National Strategy, using the preliminary outline prepared by the Fundación Ecológica Salvadoreña as the takeoff point (see pp. 5-6 of outline). The outline, however defined in its final form, must include the following elements:

- Objectives of the Strategy;
- Environment/natural resource problems in El Salvador;
- Conceptual framework for sustainable socioeconomic development, productive natural resource management, ecosystem recovery, and biological conservation;
- Consolidation of existing studies, analyses and recommendations;
- Integration of existing and ongoing projects into a cohesive program;
- Sectoral analyses of the economy and their interrelationships;
- Sector analyses of natural resources and their interrelationships;
- Institutional and legal analyses;
- Constraints to implementation;
- Establishment of priorities;
- Plans of action;
- Institutional responsibilities and coordination;
- Role of international donor agencies;
- Personnel (national and external);
- Budget;

**PROJECT
NATIONAL NATURAL RESOURCE STRATEGY TEAM**



- Calendar and timelines; and
- Monitoring and evaluation

National Data Directory

A National Data Directory should be developed that lists contents, location, and formats, and delineates responsibilities among the various institutions for data collection and analysis. The Directory should be compiled through a national conference, with a preliminary series of seminars and training workshops for the various agencies responsible for data collection. Topics to be covered in the workshops include the compatibility of geographic reporting areas; common coordinate systems and common map scales; existing databases, methods and techniques; rapidly changing technology; and costs. The theme of the seminar would be the various responsibilities for data collection and analysis and how to create an effective and integrated data and information system at the national level.

The conference would be supported by experts from agencies such as the U.S. Geological Survey, the U.S. Census Bureau, the A.I.D. Forestry Support Program, and from the private sector.

The products that result from the seminar/workshops would be the National Data Directory and the published proceedings of the conference.

National Data Collection

Another priority is the reestablishment and strengthening of a national system of data collection and environmental monitoring in accordance with the criteria and responsibilities established at the national conference on data and information systems.

Geographic Information System

A next step is the installation of a GIS to process and analyze the large amount of existing data in a comprehensive and integrated fashion and to resolve the existing problems of geographic incompatibility of reporting areas. The GIS would also process incoming new data as a result of the activities of the technical team discussed above.

Library and Information Bank

Another requirement is the establishment of a centralized library and information bank at FES to permit ready access to the large amount of research and information on natural resources and environment already available in the country. This would become a focal point of the "environmental knowledge infrastructure" as described in Daugherty et al. (1979).

Phasing of Strategy

The preparation of the Strategy would be phased to ensure maximum participation of the interested parties and the affected population. An issues paper would be prepared and debated at the end of the first three months, through a series of seminars, workshops, and public hearings. At the end of nine months, a Preliminary National Strategy would be the subject of debate at a three-day national congress. Based on input from these activities and through a continual exchange of information and ideas between the technical team and the Commission, the first Strategy document would be completed six months after the Congress, and then be subjected to debate at a second national Congress. A third Congress for presentation and formal endorsement of the Strategy would be held at the end of two years.

The products of these congresses would be The National Strategy for Natural Resource Management in El Salvador, substantial published documentation to support the Strategy, and extensive media coverage and input into the national environmental education program. Nevertheless, the formulation of a "national strategy" is an ongoing, evolutionary process that is not defined by distinct "phases" and "products," nor does it end with the final publication of a "strategy document." The real test of the Strategy will be its ongoing refinement, reevaluation, and implementation after the initial two-year preparatory phase and its continued endorsement by the government.

Formulation of the Strategy must be a participatory process. The various seminars, workshops, conferences, and congresses must ensure the active participation of cooperatives, teachers' associations, trade unions, and resource-user groups, (including womens' groups) as well as the public, private, and NGO sectors. These groups must also play a participatory role in the Presidential Commission. There are several mechanisms to do this, which can be debated, defined, and decided upon during the process of constituting the Commission.

The approximate phasing of the Strategy is shown on the accompanying Timeline (Figure 3).

Initial Projects

During the first two years of the preparation of the Strategy, initial projects would be implemented in critical areas already identified as priorities for action. These include:

- Environmental education;
- Management of biological resources/protection of biodiversity and germplasm;
- Sustainable fuelwood production; and
- Ecological rehabilitation of degraded environments.

FIGURE 3

TIMELINE

NATIONAL RESOURCE MANAGEMENT STRATEGY

ACTIVITY	MONTH	0	3	6	9	12	15	18	21	24
<ol style="list-style-type: none"> 1. Establish office of Fundacion 2. Establish Presidential Commission 3. Establish nat'l technical team 4. Appoint external counterpart 5. Establish external support team 6. Install GIS 7. Create National Data Directory 8. Library and information bank 9. Workshop on GIS/NDD/info bank 10. Define priority areas for action 11. Design initial projects 12. Implement initial projects 13. Evaluate initial projects 14. Prepare "issues paper" 15. National Congresses on Strategy 16. Define subsequent projects 17. Implement subsequent projects 18. Elaborate Strategy 										

Initial project implementation should be done in two ways: (1) projects from the four priority areas above will be defined and implemented by the technical team itself, and (2) a fund should be established for project implementation by local NGOs during the first two years. This fund would be administered by the Fundación in its capacity as the "national NGO umbrella organization," and based on criteria established by the Board of Directors and the Technical Committee of the Fundación and by USAID. An additional and substantial fund should be directed specifically to environmental education at the local and national levels in both the formal and nonschool education sectors.

Initial project implementation is based on the conviction that many of the critical environment/natural resource issues can be immediately addressed without additional data or study. Furthermore, the results of initial project implementation would be integrated into the evolutionary process of Strategy formulation. This methodology of "action-research" and "action-learning" allows the continual input of project results into policy formulation. Furthermore, the credibility of the Strategy process and the technical team can be strengthened by the expertise demonstrated by the team in the design and implementation of short-term projects that have immediate and visible impact — a critical point for maintaining the support of the Presidential Commission. Thus, there would be the parallel actions of Strategy formulation and project implementation, each reinforcing the other, and validating the process.

Initial project implementation would also forcefully strengthen the local and national NGO movement in El Salvador. This movement has the potential to become the major catalyst for environmental education at all levels and for sound natural resource management at the local level, with the most direct and visible impact on the quality of human life.

Research Infrastructure

Implicit in the formulation of the Strategy is the establishment of a research infrastructure that would begin to undertake quantitative data analysis to provide a stronger basis for decision making in terms of costs and benefits of various courses of action (logical framework analysis), trade-offs, and externalities. The economic as well as the ecological future of this country depends upon sound resource management decisions based on sound research results that integrate economics and ecology.

The creation of such an applied research infrastructure requires the reestablishment of data collection and monitoring of major environmental parameters, the strengthening of the analytical capability of the institutions involved, and the implementation of a GIS which is a powerful tool for research and decision making vis-à-vis resource planning, management, implementation, monitoring, and evaluation.

Human Resources

A critical factor in the long-term impact of the Strategy is the development and strengthening of the human resources (scientific, professional, managerial, and administrative) required to implement, coordinate, and consolidate the Strategy. Thus, a major initial step in the Strategy will be to identify the human resource needs and to develop a plan of action to meet these needs through graduate training abroad; in-country, short-term training; and in-service training. A fundamental component of this training should be through an exchange of information, ideas, and personnel along a newly

aligned south-south axis, rather than the conventional north-south transfer, to capitalize on the rapidly expanding experience and expertise in other developing countries.

Key Institutions

The key public sector institutions involved in the elaboration of the Strategy are:

- Ministry of Agriculture
- Ministry of Planning and Coordination of Economic and Social Development
- Ministry of Education
- Ministry of Public Health
- Ministry of Defense
- Asociación Nacional de Acueductos y Acantrillados (ANDA) (national water utility)
- Comisión Ejecutiva Hidroeléctrica del Rfo Lempa (CEL) (national power utility)
- National Geographical Institute (IGN)

Other important institutions are the various universities including the Universidad de El Salvador, Universidad Centroamericano "Jose Simeon Canas," Universidad Salvadoreña "Alberto Masferrer," and others. Particularly important is the Biology Department at the Universidad de El Salvador, which has several specialists in various natural resource management fields and which has trained most of the personnel in the national park service.

NGOs include Movimiento Ecológico Salvadoreño, Asociación Salvadoreña de Conservación del Medio Ambiente, Fundación Teclena del Medio Ambiente, Fundación Montecristo, and Amigos del Arbol.

The above would provide technical support and expertise in varying degrees and have a supportive role such as providing access to data, information, and personnel. Potential involvement of the international community (bilateral, multilateral, and NGO) is anticipated in a similar supportive role, as well as being a major source of funding for the implementation of the Strategy.

DATA AND INFORMATION NEEDS FOR A NATIONAL STRATEGY

A natural resource strategy is a method of managing resources to achieve a sustainable yield in the case of renewable resources and a rational exploitation in the case of nonrenewable ones. In the case of degraded resources, a strategy may imply projects to reverse the degradation. Information is essential in either case as both require that decisions be made as to where action should be taken, what kind of action, and how much. These questions can only be answered properly if there is an inventory and monitoring of the existing resources base.

Two major problems exist with current data in El Salvador to support development of a natural resources strategy. One is lack of recent time series data. Most data collection activities were affected by the onset of the war in 1980 and 1981, and consequently there are many gaps in the data. The significance of this problem is that lack of time series data precludes quantitative assessment of

environmental deterioration in El Salvador. Rates of change and indicators of major problem areas cannot be calculated. This hiatus in data collection affects, to a greater or lesser extent, all offices that were visited. This problem can be overcome for certain types of data by surrogate methods that are detailed below in the inventory. For other data, the only solution is to begin to collect data again. When data collection efforts begin anew there is an opportunity to address the second problem.

The second problem is lack of compatibility in statistical data in terms of both format and reporting areas. Databases exist in at least three different programs, each with its own format. Format problems are not difficult to overcome as the programs have the capability to output data in ASCII format. However, potential for duplication of data is large. There is also a large variation in statistical reporting areas. For example, different ministries have their own statistical reporting areas that do not correspond to other ministries or to standard administrative boundaries such as departamentos or municipios. These two aspects of data incompatibility contribute to the inability to compare different data sets in order to understand interrelationships. For example, any relationship between pesticide application rates and water quality measurements at a particular monitoring station cannot be made easily. Only data organized on a geographically compatible basis permits the analysis of such a relationship. Some common statistical reporting area such as the municipio should be used by all data collection agencies when collection resumes. The importance of this has been recognized before. The strategy for A.I.D. assistance to Central America for environmental and natural resource management states:

A means is needed to collect, store, retrieve and analyze natural resource information on a regionally standardized basis (USAID, 1988b, p. 43).

Inventory, Problems, and Prospects of Existing Data

In spite of the suspension of data collection activities, a great deal of existing data is usable for development of a national strategy. The following is an analysis of existing data and of its suitability to support a natural resource strategy. Problems with existing data, where appropriate, are indicated and suggestions for future collection efforts as well as recommendations for using certain data sets in combination with others are provided.

Instituto Geográfico Nacional (IGN)

The topographic map base of the IGN at a scale of 1:50,000 exists for the entire country in 58 sheets. IGN is also preparing a digital database of national cadastral information using an INTERGRAPH system. This digital database is at a large scale (> 1:10,000) and is concentrated in the urban areas of San Salvador. The director of the Cadastral project stated that there was a database, but we were unable to obtain a list of data items. The U.S. Geological Survey produces digital cartographic products in a format called digital line graph. These products are organized by themes such as stream centerlines, road and street centerlines, survey information, and so forth. IGN could use the existing INTERGRAPH system to produce similar digital files that could be used in a GIS. Also files of elevation locations such as bench marks and triangulation stations could be used to generate digital elevation models (DEM) of the country, or portions of it. A DEM is a mathematical description of the location of an area in terms of x, y, and z (elevation) values. DEMs are used to generate slope and aspect polygons. A slope polygon is an area with the slope within a certain range

of values such as 15-18 percent slope. Slope is a fundamental parameter for estimating potential for soil erosion. Aspect refers to the orientation of a hillside to the sun. Aspect along with slope determines the amount of solar insolation incident on a particular area and thus influences soil moisture balance and plant growth. Another important digital product that IGN could produce would be administrative boundaries to include departamentos, municipios, cantones, and caseríos.

The production of these types of data files by IGN implies a close cooperation between the agency charged with the elaboration of the strategy and IGN. The fact that IGN is producing digital files means there exists in El Salvador a commitment to organize data in a manner compatible with computer handling. There only remains the effort to extend this data organization to data collected by agencies other than IGN. The U.S. Geological Survey may have technical assistance programs that could reinforce the IGN effort.

Comisión Ejecutiva Hidroeléctrica del Río Lempa (CEL)

CEL has satellite image processing capability and has conducted pilot land use interpretations in support of firewood studies. The image processing system is called ERDAS and runs on an IBM AT. CEL is currently using thematic mapper data from the latest LANDSAT satellite. If the United States phases out the LANDSAT program, then other sources of data will have to be sought. France has a satellite called SPOT that is capable of providing data. The thematic mapper data has 30 meter resolution and senses in 10 separate bands of the electromagnetic spectrum. SPOT data has 10 meter resolution, which means that for each band there exists nine times the data that would exist for a comparable area in thematic mapper data. This implies that data storage for future information systems should be carefully considered.

Image processing systems are capable of different types of analysis such as land use/land cover interpretation, crop identification, or vegetation cover interpretation. These types of interpretations have to be supported by field research and sampling techniques to achieve the highest possible levels of accuracy. Area sampling frame methodology (see below, Ministry of Agriculture) requires that field samples be done in conjunction with image interpretation in order to extrapolate results of crop inventories to other areas. Field research supplements interpretation by identification of crop appearance on the imagery under differing conditions of crop stage and stress. Image processing systems are also capable of periodic monitoring. The LANDSAT satellite passes over the same spot on the earth's surface every 18 days. For continuous monitoring of erosion status or crop inventory, data could be ordered every year and analyzed.

Centro de Recursos Naturales (CENREN), Servicio de Hidrología y Meteorología

The Servicio has recently acquired the CLICOM computer program from the World Meteorological Organization that will permit them to analyze data by a personal computer. This program is integrated with the DATAEASE program that serves as the database manager. The Servicio is now inputting existing monthly meteorological measurements. At one time the Servicio had as many as 250 rainfall stations operating in the country. Now there are 20. Many of the stations have ceased data collection with the onset of the war. Before the war there were more than 50 stations with over 50 years of continuous measurements. Some stations have hourly rainfall data that would permit rainfall intensity calculations for the Universal Soil Loss Equation. It may be possible to derive

surrogate indications of rainfall amounts for years when data are missing by the use of satellite imagery taken during those same years. This would require assessment of vegetation vigor. However the cost of this type of assessment would likely be high if the imagery for these years even exists. This is an example of time series data that have to be taken at a particular time or the opportunity is lost and the time series is weakened. The CLICOM program allows output of isoline maps that require a locational base for the meteorological stations. This locational base should be in a recognized coordinate system such as geographic or Universal Transverse Mercator grid so that it matches other data sets with a locational component.

CENREN, Ordenación de Cuencas Hidrográficas y Conservación de Suelos

This office has a soil survey at 1:50,000 for the entire country based on an older soil classification system called Great Groups. This survey can be used until an update can be done according to the Seventh Approximation classification system of the U.S. Department of Agriculture. While the scale of 1:50,000 is sufficient for the purposes of a national strategy, it is too small a scale for the use of agricultural extension workers in the field to develop individual farm plans. An updated soil survey could be helped by the type of image interpretation being carried out by CEL. Many specialized training courses are provided in the United States for this particular application of remote sensing. A land capability classification also exists for the entire country that uses the U.S. Department of Agriculture system of eight different categories ranging from soils with few limitations to soils with limitations that cannot be corrected. Also needed is a soil erosion inventory that categorizes levels of erosion, areas, and locations. This could be carried out, again, with help of the image processing system.

CENREN, Servicio Forestal y de Fauna

This Servicio has a map based on satellite imagery of forest lands, coffee plantations, and mangrove vegetation areas. Apparently, the national office of CENREN has little real power, this being decentralized in the various regional offices of the Servicio. This appears to apply to data collection efforts as well.

Ministry of Agriculture

MAG has been using area sampling frame methodology to inventory large areas of the country. This methodology uses satellite imagery and sometimes aerial photography to outline areas of similar appearance (photomorphic units). These photomorphic units are then sampled as to content. Field teams are sent out to sample range condition, crop condition and hectarage, timber volume, and so forth to quantify agricultural and vegetation resources. Accuracy of results can be balanced with costs. If a higher level of accuracy of results is required, then more time can be spent in the sampling effort. Problems of uniform statistical reporting areas are applicable.

Dirección General de Estadística y Censos

The last population census was taken in 1971. Another population census was planned in 1981 but was never carried out because of war. Dr. Raúl Toledo of USAID/El Salvador used the housing census carried out in the years between 1978 and 1980 to estimate 1980 rural and urban populations by departments. Population projections to the year 2020 based on the 1971 census were prepared using an age cohort model. Growth rate assumptions were high, low, and recommended. These projections were for the entire Salvadorean population and were not disaggregated by geographic area or by rural/urban classification. A population census is planned for either 1990 or 1991. An interim solution is to count housing units on recent aerial photographs, and combine this data with estimates of persons per dwelling unit based on field survey, to statistically estimate population. Satellite imagery with land use interpretations can also supplement this method. The ideal would be to have a recent census disaggregated to the municipio or canton level with socioeconomic indicators such as incomes, sanitation, nutrition, and health. These data could be compared with other data by location.

The U.S. Census Bureau could provide technical assistance for the 1990 census. The Census Bureau, in conjunction with the U.S. Geological Survey, has developed a digital cartographic format for the maps that will accompany the 1990 United States census. This format is called TIGERS (Topologically Integrated Geographic Encoding Reference System). An opportunity to develop a similar product for use with the El Salvador 1990 census may be considered in conjunction with IGN.

Ministry of Public Health

The Ministry of Public Health has a laboratory for chemical and biological analysis of water samples, but there are few water monitoring stations. Data collection efforts were disrupted by the war. This collection effort should be resumed as soon as possible in order to reestablish the time series to assess changes in water quality parameters. Air quality monitoring stations have not been established at all. Because of so many other needs, it may be advantageous to invest in other forms of data collection.

Asociación Nacional de Acueductos y Acantrillados

ANDA is the national water agency of El Salvador. They have a database in Dbase that contains information on ground and surface waters. The database contains parameters such as depth to ground water and well logs. A data dictionary with individual data items was requested by the authors. ANDA also has a computerized ground water model. Some well locations have been plotted on national topographic maps.

Water Database at USAID

This is a database constructed with USAID funding that is based on MAG regions, subregions, and major watersheds. Much of this information could serve as data for a geographic information system. This would allow the graphic representation of the spatial variability of the data. It appears that at least part of this database is in Lotus, which does not support data base normalization, a method of organizing data that eliminates the majority of data duplication.

Pesticide Database

This is a database that may be constructed with USAID funding. If it is constructed in Lotus, then the same problems of data normalization are encountered as those in the water database. The amount of data that may be included — pests, history, growing season, crops, pesticide action, toxicity — suggests that some thought should be given to use of a more appropriate database manager (such as a relational database manager) and to the design of the database.

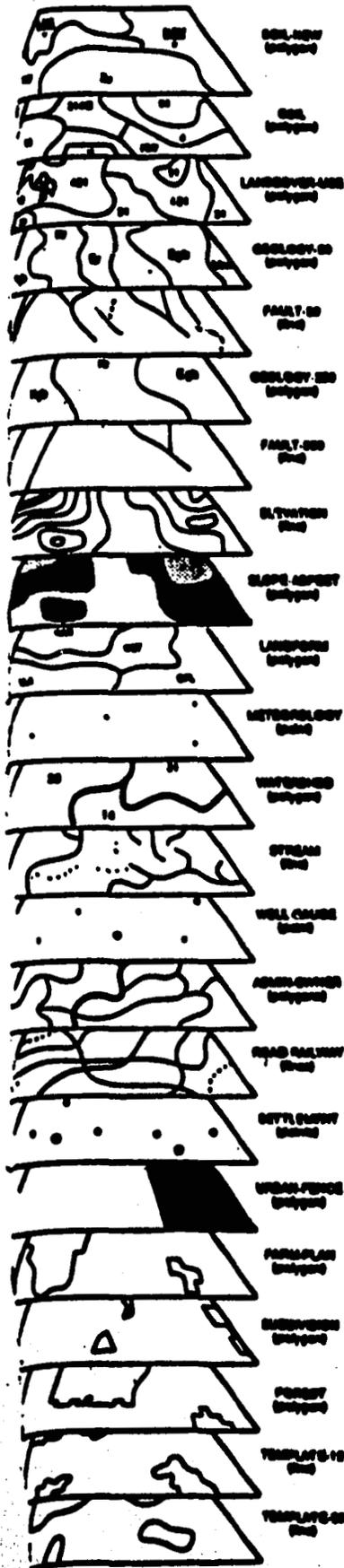
Use of the Geographic Information System

Opportunities to use the large amount of existing data in an integrated fashion and to resolve problems of geographic compatibility in the reporting of data can be accomplished through the use of a GIS. Often a simple graphic overlay of different data sets onto a common locational base can suggest or clarify spatial relationships (Figure 4). However two capabilities of a true GIS extend analytic power beyond that of graphic overlay. First, a GIS links cartographic representations (points, lines, polygons) of geographic features to a relational database management system. The database management system (DBMS) can store large amounts of information about the cartographic representations (Figure 5). For example, measured water quality parameters can be stored for a point that represents the location of a water monitoring station. Storage of attribute data in a DBMS permits the systematic analysis of large amounts of data for decision-making purposes. Often existing information is ignored because its volume is too great. A second major capability of a true GIS is that of establishing topological relationships among the map features (Figure 6). Which rivers (cartographic lines) are connected to water monitoring stations (cartographic points)? What is the relationship between pesticide application rates on areas (polygons) bordering those rivers? These are examples of questions that can be answered through topological relationships.

Installation of a GIS could be done in any of several existing organizations. CENREN would be a logical choice as it is charged with the responsibility of developing all natural resources. CENREN would require substantial reinforcement as an institution and cooperation with other organizations such as IGN and CEL should be encouraged. Acquisition of GIS components could be done to allow expansion of the basic system after development of the natural resources strategy, so that other institutions could take advantage of GIS functionality.

Costs vary greatly for GIS systems. A system that could function on an IBM AT that CEL uses for image processing system could be procured for as little as US\$10,000 plus training costs of approximately two weeks (US\$6,000 to US\$7,000 for on-site training). A workstation system that could serve as a core system (capable of expansion) could cost between US\$50,000 to US\$100,000, depending on the exact configuration. There are costs associated with data automation, but this could be done with local labor after minimal training (IGN may be able to provide some training based on their data conversion efforts).

Figure 4
Summary of the Map Library



Library Name: JAMAICA

**Tile Structure: 12 tiles based on 1:50,000
 scale topographic map series**

**Projection: Lambert Conical Orthomorphic
 with one standard parallel**

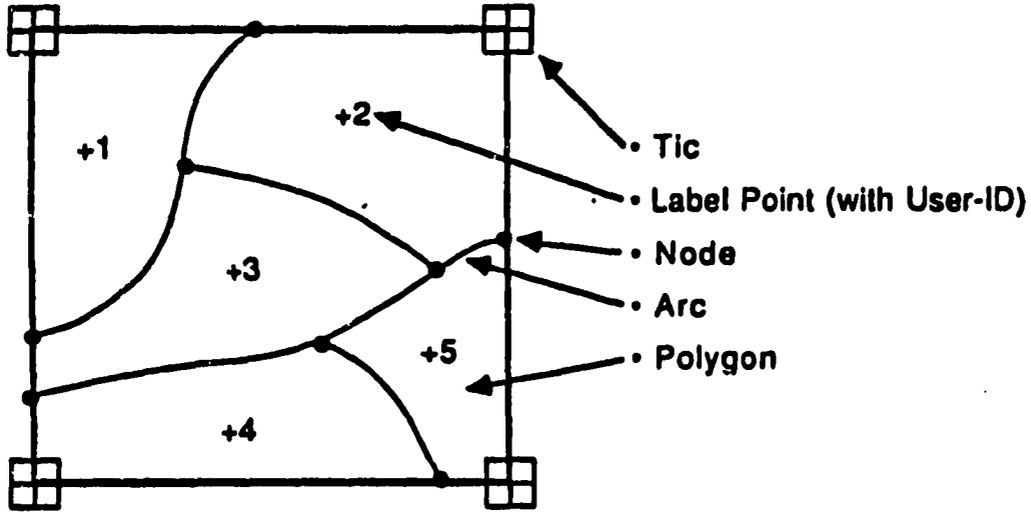
Coordinate System: Lambert Feet

Number of Layers: 22

Number of Items (variables): 64

Number of Look-up Tables: 10

Figure 5
Example ARC/INFO Coverage



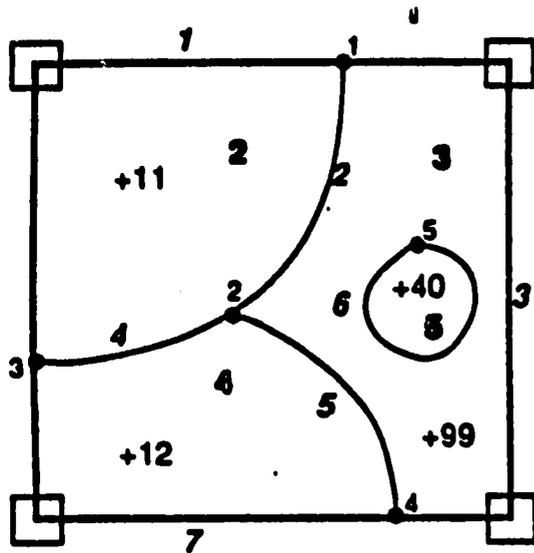
Polygon Attribute Table

User-ID	Soil Type
1	4
2	77E
3	29A

Soil Type Look-Up Table

Soil Type	Texture	Drainage	Depth
4	01	1	24
29A	03	4	12
77E	12	2	18

Figure 6
Coverage Topology



- Node
- 2 Node Internal Number
- 2 Arc Internal Number
- 2 Polygon Internal Number
- +12 Label Point User - ID

Polygon Topology

User-ID	Polygon #	Arc #
	1	1,3,7
11	2	1,2,4
99	3	3,5,2,0,6
12	4	5,7,4
40	5	6

Node Topology

Node #	Arc #
1	1,2,3
2	2,4,5
3	1,4,7
4	3,5,7
5	6

Arc Topology

Arc #	From Node	To Node	Left Poly	Right Poly
1	1	3	2	1
2	2	1	2	3
3	1	4	1	3
4	2	3	4	2
5	2	4	3	4
6	5	5	3	5
7	3	4	4	1

CONCLUSION

The preparation of a National Strategy for Natural Resource Management in El Salvador can proceed on the basis of already established foundations. The Salvadorean government appears to be firmly committed to undertaking concrete action to strengthen resource productivity and sustainability. There are several environmental NGOs that are young and dynamic, with qualified leadership and personnel, and there is a groundswell of public opinion spearheaded by the mass media regarding rapidly deteriorating environmental quality.

At the regional level, the five Central American presidents, during the Tela Summit in July 1989, recognized the critical nature of resource management problems and the need to reverse the trend of environmental degradation throughout the region, emphasizing the interrelationships between economic productivity, ecological enhancement, and sociopolitical stability. The Salvadorean Minister of Agriculture is playing a leadership role in the creation of a regional presidential commission on resources and environment, as agreed upon at the Tela Summit.

This regional activity accords with the reports of the Kissinger Commission and the Sanford Commission, and with the recommendations of the Central American Environmental Profile. It also accords with A.I.D.'s Regional Strategy on Environment and Natural Resources, and indicates the rapidly growing awareness of the intricate relationship between economics, ecology, and human well-being in Central America.

What is lacking in El Salvador, specifically, is a catalyst to mobilize and channel the human resources of the country along a new path to sustainable development focusing on human needs, sustainable natural resource management, and ecological recovery — in solidarity with the Esquipulas and Tela Accords. A.I.D. now has the opportunity and challenge to be that catalyst.

USAID/El Salvador has accepted that challenge and is "committed to implementing the Agency's Environmental and Natural Resources Policy and fully endorses the Central America Environment and Natural Resources Strategy" (USAID, 1988b, p. 3). Furthermore, the Mission "proposes to implement its program within a framework of (1) policy dialogue with the government of El Salvador, (2) development of private institutional capacity, (3) human resource development, and (4) support for selected project and non-project activities" (USAID, 1988b, p. 3).

The initial design for the National Strategy for Natural Resource Management of El Salvador contained in this report meets the four Mission objectives outlined above. It is based upon policy established at Agency and Bureau levels and accords with the USAID Strategy for Environmental and Natural Resource Management in Central America. It also contributes strongly to the stated strategic goal of providing AID assistance to Latin America and the Caribbean countries for environmental and natural resource management and sustainable agriculture.

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