SUPPORT

to

U.S. DEPARTMENT OF STATE'S
BUREAU FOR INTERNATIONAL NARCOTICS MATTERS

on

ENVIRONMENTAL IMPACT OF ILLICIT NARCOTICS CULTIVATION IN SELECTED FOREST REGIONS OF LATIN AMERICA AND THE CARIBBEAN BASIN

July 17, 1987

from

BATTELLE

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INTRODUCTION

The U.S. Department of State's Bureau for International Narcotics Matters (INM) has devoted considerable attention and effort to influence the control of illicit drug production outside the United States. One strategy of INM is to illustrate to foreign leaders the environmental and associated economic consequences of continued production of the illicit crops. INM desires to continue and enlarge on this strategy.

In particular, many of the growing regions for these crops are located in fragile ecosystems. The growing regions to be included in this program often are located in tropical or subtropical climates on steeply sloped, highly erosive, thin, and leached soils with virgin woody species cover. Deforestation and certain other agricultural practices in these environments are known to have devastating short- and long-term effects on the environment, and on related socioeconomic factors (Figure 1). Among other

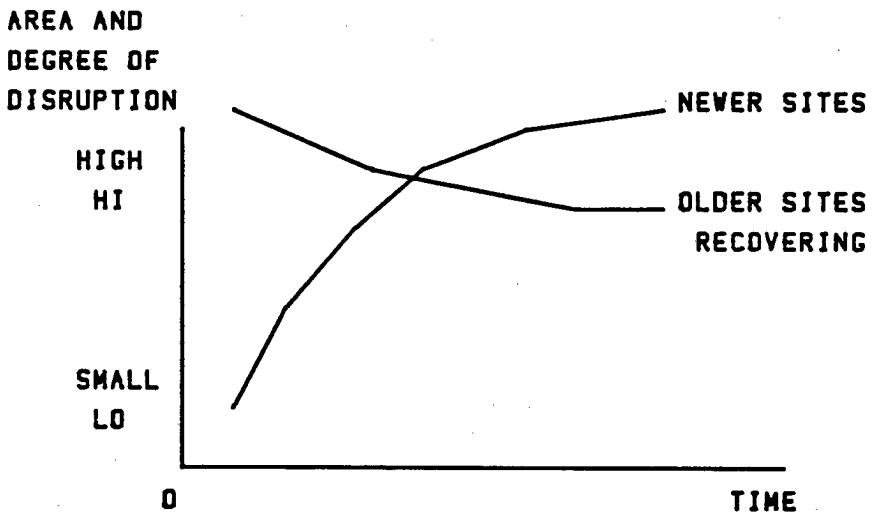


FIGURE 1. THE DEVASTATING ENVIRONMENTAL AND SOCIOECONOMIC CONSEQUENCES OF DEFORESTING AGRICULTURAL PRACTICES ARE RAPID, AND RECOVER SLOWLY

negative consequences, deforestation interrupts for extended periods the intricate and balanced primary and secondary productivity of tropical soils, flora, and fauna. Destruction of genetic resources (germplasm) also is an important consequence of tropical deforestation.

INM has requested that Battelle prepare this white paper with a view toward providing technical and economic information which can be used to support INM's strategy.

The focus of this program is to identify and assess the natural and economic resource effects which result from growing the illicit crops in the countries of interest. The output should support U.S. policy development, be country-specific, and have a material bearing on the leaders' decision-making with respect to active inhibition of illicit crop production. The major emphasis of this program is on direct environmental and economic effects. Lesser emphasis would be placed on effects of a very small scale (i.e., on the grower) or on macro-scale issues (i.e., global climate).

This document describes our understanding of the program's objectives and scope, our suggested approach for meeting the objectives, the anticipated program output, a preliminary schedule of activities, and a description of the core program team members and their experiences.

OBJECTIVES AND SCOPE

The primary objectives of this program are to:

- Identify, describe, and document for the regions of interest the major environmental consequences, and the related economic implications, of the production of illicit drug crops. This information will be used to encourage leaders to actively inhibit illicit crop production.

Our goal is to create a tightly focused program yielding highly usable results. The results also can establish a framework for future programs that can focus on other aspects of the problem. To that end, several elements delineate the scope of the program.

- Geographic Regions. The spatial focus of the program includes the mountainous areas of western Jamaica, the Santa Marta and/or Perija Mountains of Colombia, and the Huallaga Valley of Peru that currently or potentially are impacted by illicit marijuana or coca growing. [Selected Bolivian sites may be considered as alternates to the Peruvian sites.] The areas included in this geographical focus collectively can be termed "affected regions". More detailed geographic descriptions of the focus regions need to be developed through discussion with INM. There will be a need for analysis on an affected region basis, as environments and likely effects differ among the regions.

- Crops. Marijuana and coca are the crops of interest in these regions.

- Environmental Implications. We will be focusing on examining direct effects (changes of vertical and horizontal aspects of vegetative cover, soil fertility, local erosion, flooding, in-stream sedimentation, loss of nutrients from burned vegetation, recovery rates on growing areas, etc.) of both short- and mid-term nature. Indirect and long-term effects, such as possible changes in fauna, climate, atmospheric conditions, etc. would receive less attention in this program (Figure 2).

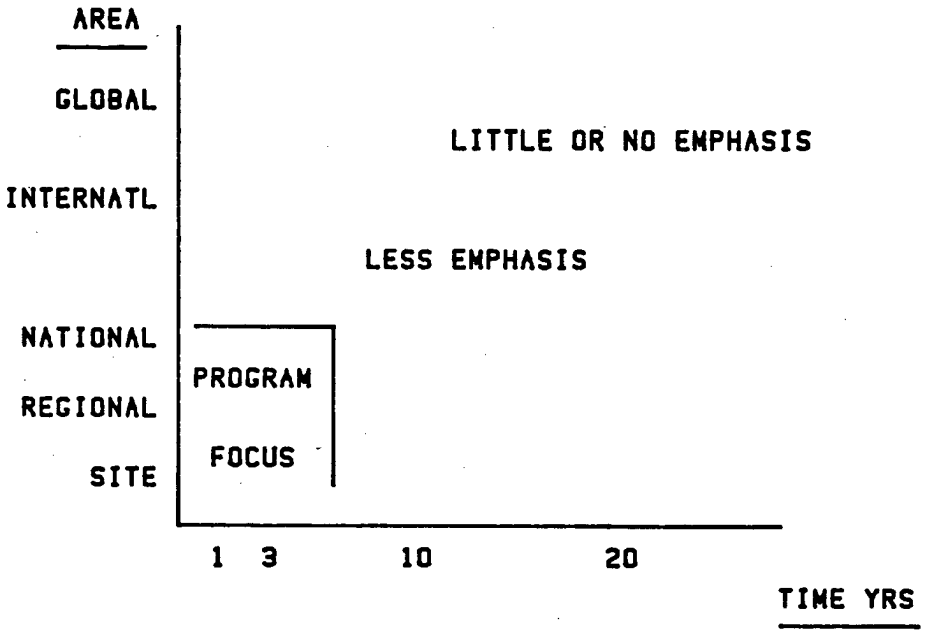


FIGURE 2. THE FOCUS OF THE PROGRAM IS ON NATIONAL "AFFECTED REGION" BASES, AND ON NEAR- TO MID-TERM AFFECTS

- Economic Implications. This element is designed to allow us to integrate and convert the findings from the environmental analyses to economic variables and descriptions. Based on examination of specific country-crop combinations (e.g., marijuana growing in Jamaica), we hope also to be able to draw conclusions across countries and across crops so as to provide an integrated picture of environmental and economic consequences (Figure 3).

  As with environmental effect descriptions, we will be examining direct as opposed to indirect or distant effects. In this program, we will concentrate first on the implications to the drug-growing region of the producing country, giving lesser attention to its growers, alternative employment, and alternative crops. Downstream social costs in the countries of consumption are outside the scope of this program.

- Costs and Benefits. This program is not designed to be a formal cost/benefit analysis. Costs and benefits will be monetarily quantified within the context of supporting policy, and when sufficient supporting documentation is available. Otherwise, costs and benefits will be stated in environmental and socioeconomic terms on a per unit basis for affected regions (e.g., loss of soil or nutrients per hectare; hectare-years of site destruction). We will express the observed and measured costs of illicit crop growing on a regional basis since each cropping site affects areas beyond the actual site borders through in-stream sedimentation and other processes. We believe that focusing on the overall costs to the regions that support illicit crop growing, rather than on the costs to individual illicit crop plots will provide INM with results more central to its needs.

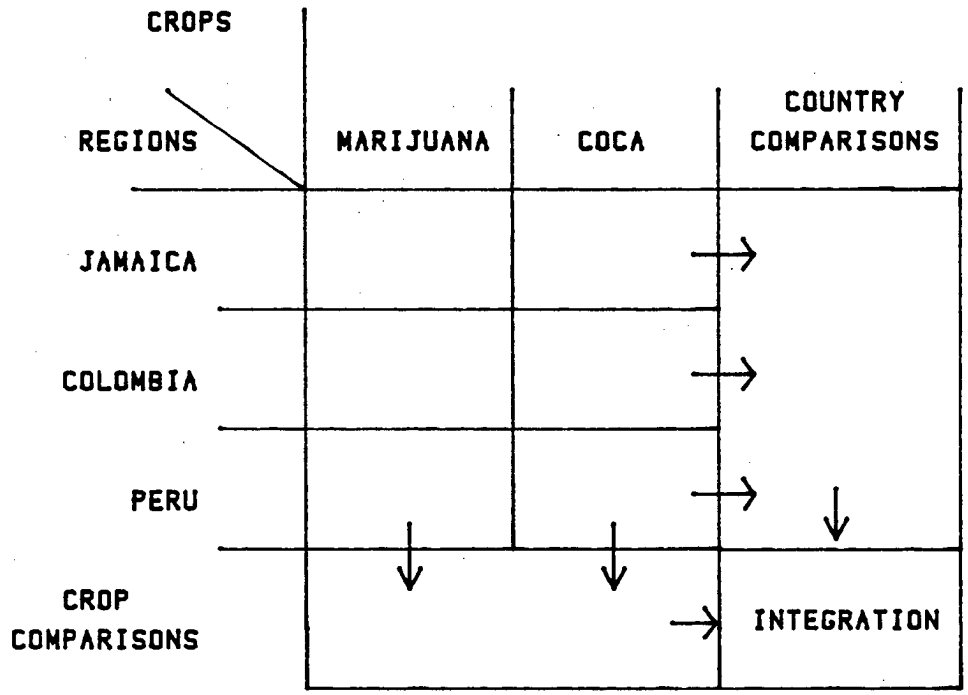


FIGURE 3. OUR GOAL IS TO PROVIDE INTERCOUNTRY, INTERCROP, AND INTEGRATED DESCRIPTIONS OF CONSEQUENCES BASED ON EXAMINATION OF SPECIFIC CROP-COUNTRY COMBINATIONS

ANTICIPATED RESULTS

We anticipate being able to provide the following to INM:

- Descriptions in the affected regions of the direct near- and mid-term environmental effects to soils, vegetation, and waterways, and the associated economic implications of growing the illicit drug crops. The major emphasis will be on the environmental impacts of the illicit agricultural systems, placed in an economic context.

- Documentation supporting the effects and implications through review of the scientific literature, photographs, on-site sampling and analyses, and interviews with local and international experts in the field. Where possible, 'before and after' analyses will be depicted.

- A concise report of our key findings designed to meet the needs of several audiences, including INM and the political leaders (provincial, parish, national) in the countries of interest. The scientific and technical support to our conclusions and implications will be provided in appendices.

- Report supplements in the form of captioned 35 mm slides usable for audiences with foreign leaders and in other contexts.

APPROACH

We suggest an eight-task approach in this program. This will allow for an orderly development of information to reach our anticipated results. These tasks and their interrelationships are described below.

Task 1. Detailed Planning and Resource Identification

It is vital during this task that the detailed planning effort already initiated be completed, including the further identification of available resources for effectively conducting the program. Such resources include the inventory of Government (e.g., INM and Drug Enforcement Agency) data and reports, photographs, satellite imagery, and possible lists of interviewees located both in the U.S. and in the countries of interest. INM should participate in this planning/resource task not only as a resource, but also to assure that the final plans remain directed to INM's specific needs. This program (its objectives, time, budget, etc.) is not amenable to major changes in direction, repeat of tasks, or multiple field visits to the same sites.

Task 2. Identification and Retrieval of Published Literature

Considerable quantities of literature have been published on the environmental and economic consequences of deforestation. For example, Battelle staff have published approximately 20 technical reports/articles on tropical environments including co-authorship of a book on nutrient cycling in tropical forests in Panama. Articles have dealt with soils, nutrient budgets, and vegetation patterns. Little literature, however, has focused on deforestation specifically related to illicit drug production. Nonetheless, the existing literature on deforestation and ecosystem perturbations will provide valuable baseline information for this program. We anticipate that the baseline information will assist in identifying categories of effects, and in identifying differences between environmental effects created through illicit drug agriculture and through other activities. From the current

literature, we will establish categories of expected environmental consequences of slash/burn agriculture and clear-cut forestry on typical sites in each of the affected regions. Of particular interest will be work conducted on recovery rates of various disturbed ecosystems, and the effects of slash/burn agriculture and clear-cut forestry on erosion of soil and release of nutrients. For example, the effects of in-stream sedimentation in the tropics only now are being documented well.

During our field work, we then can focus on confirming the presence or absence of these effects in the illicit drug agriculture sites, and on identifying and quantifying any differences between baseline sites and illicit drug agriculture sites. We anticipate that illicit drug agriculture will be found to be more destructive than normal slash/burn agriculture or clear-cut forestry because the illicit drug agriculture sites typically are located on more marginal land and the growers tend to abandon sites, showing little concern for long-term environmental effects.

Establishing a link between our analysis of destruction in illicit drug agriculture sites and those provided in the current literature for other types of slash/burn agriculture and clear-cut forestry sites will enhance credibility, given that a long-term study cannot be implemented at this time. Much of this literature is on-hand at Battelle from prior studies. Literature on a number of other topics also will be identified and retrieved. A literature search strategy will be developed early in this Task using input from Task 1. We have on-line access to the international literature databases, and have established methods for rapid retrieval of desired references. Particular attention will be paid during literature retrieval and analysis to identifying persons both in-country and elsewhere for productive interviews. A first-cut list of candidate in-country (faculty) interviewees has been started and is presented in Appendix C; other categories of candidates need to be developed. Much of Task 1 and Task 2 will be conducted concurrently.

Task 3. Preparation and Preliminary Analyses of Available Resources

As a result of Task 1, it is expected that some preparation and analyses of available resources will be required. For example, it may be desirable to compare satellite imagery of the same location taken on two or more different dates. We anticipate that this analysis will require preparation time by Battelle Northwest or the current INM contractor providing the service.

The second portion of this Task constitutes preliminary analyses of the resources acquired in Tasks 1 and 2. The results of the preliminary analyses will enable tentative conclusions or hypotheses to be formulated and a series of questions to be developed. The hypotheses will be tested and the questions addressed during the field visits and interview tasks.

The final step in this task is to review the plans generated in Task 1 and the analyses of the literature retrieved. We will make any necessary changes to the plans, and finalize preparations for the remainder of the program.

Task 4. Selected U.S. Interviews

The earlier tasks will identify possible contacts within the U.S. and questions to be posed to these persons. During Task 4, these resource persons in the U.S. will be contacted by telephone and, if necessary, through field visits. In particular, telephone contacts and possibly field visits should be considered to the University of California at Santa Barbara and to the University of Mississippi. We have worked previously with six additional centers for knowledge of tropical ecology, and know many of the key persons in the tropical sciences. For example, we may contact Dr. Peter Raven, President of Tropical Biology Association and Dr. Daniel Janzen, one of the world's leading tropical biologists. Our existing contacts may aid us in identifying additional in-country resource persons.

Task 5. Jamaican Field Visit and Interviews

For several reasons (including language, proximity, etc.), we suggest that the initial field visit be to Jamaica. The following activities will be necessary:

- arrangements and logistics for visit (with the assistance of INM)
- interviews with information resource persons
- fly-over and on-ground visits to selected sites representative of various conditions and stages of growth, including current illicit crop sites, previous illicit crop sites, undisturbed (virgin) sites, and legal crop sites (Figure 4)
  - still color photography
  - collection of soil, tissue, and other samples and measurements, such as length and degree of slope, soil depth, and percent vegetative cover
  - comparisons to previous data from the site or nearby.

This task will be completed upon organization and consolidation of the information retrieved from Jamaica and after any necessary changes in planning to improve the next set of field visits.

Task 6. Colombian and Peruvian Field Visits and Interviews

The information needed on the visits to Colombia parallels that of the earlier Jamaican field visit described above. However, particular attention will be paid to differentiating between our findings in Jamaica and Colombia with respect to marijuana growing, and to the coca plantations of Peru. We consider it especially important to distinguish between the marijuana and coca agricultural systems, as we suspect that there are important differences in the two relating not only to physical but also to illicit crop-cultural considerations. For example, it appears that the long-standing Peruvian peoples' habitual chewing of coca leaves creates a greater social

INTRACOUNTRY COMPARISONS BY CROP AND CROP SITES

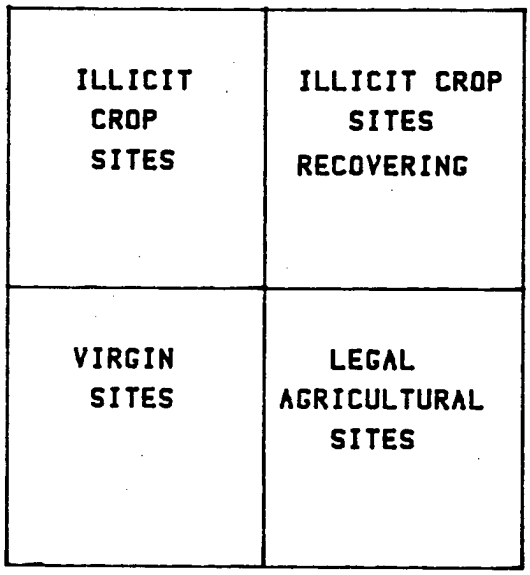


FIGURE 4. ON-SITE VISITS SHOULD BE MADE TO VARIOUS SITE TYPES TO ALLOW COMPARISONS OF EFFECTS

toleration of coca growing by local authorities. This cultural toleration enables coca production to occur on somewhat higher quality lands. The use of these higher quality land types may create differences in environmental considerations and implications. Also, the coca plant is cultivated as a perennial, giving the growers incentive to preserve the quality of the cropping sites for longer periods of time in certain environments.

Task 6 will be completed after organizing and consolidating the information retrieved through the field visits.

Task 7. Analyses and Implications of Findings

Task 7 is the major analytical Task. It begins with a structuring and organization of the findings from the literature, the interviews, the field visits, and other sources. In conducting the analyses, we will be looking for representative evidence supporting (or not supporting) the tentative conclusions and hypotheses generated in Task 3.

We expect to use a simple ranking system (high, medium, low) to better translate this knowledge into meaningful, lay-language findings. For example, we may be able to report a high extent and high magnitude consequence in certain regions, a low extent and low magnitude consequence in other regions. A similar, simple approach to organizing environmental and other data and information was presented by one of the Battelle core team members at CETESB in Sao Paulo, Brazil. Out of this will flow levels of environmental concern and economic priorities. Given our findings at this stage, we will begin to draw formal conclusions relating to the environmental and economic implications of growing the crops in the regions of interest. Meaningful implications will be described qualitatively and, where possible, quantitatively and monetarily.

This Task closes with a detailed outline of our findings, implications, and reporting frameworks. It would be useful at this point to schedule a meeting with INM so as to formally review progress and finalize plans with respect to the content and nature of reporting.

Task 8. Reporting

We suggest that two reporting formats be utilized:

- Written Report in Two Volumes. The first volume would be a concise set of three "executive summaries" organized by country, consisting of five to ten pages each which might be distributed to local leaders. We suggest that this first volume be written in lay language, be hard-hitting in a credible way, and contain color photographs and presentation graphics in support of key findings. The second volume (or a set of appendices), would provide the discussion and documentation in a more technical format supporting the conclusions and implications contained within the executive summaries.

- Visual Aids. The second reporting format would consist of sets of slides organized and separable by country. Narration-style captions would accompany the slides. These visual aids would be accompaniments to the appropriate executive summary, and could be used in face-to-face discussions with foreign leaders.

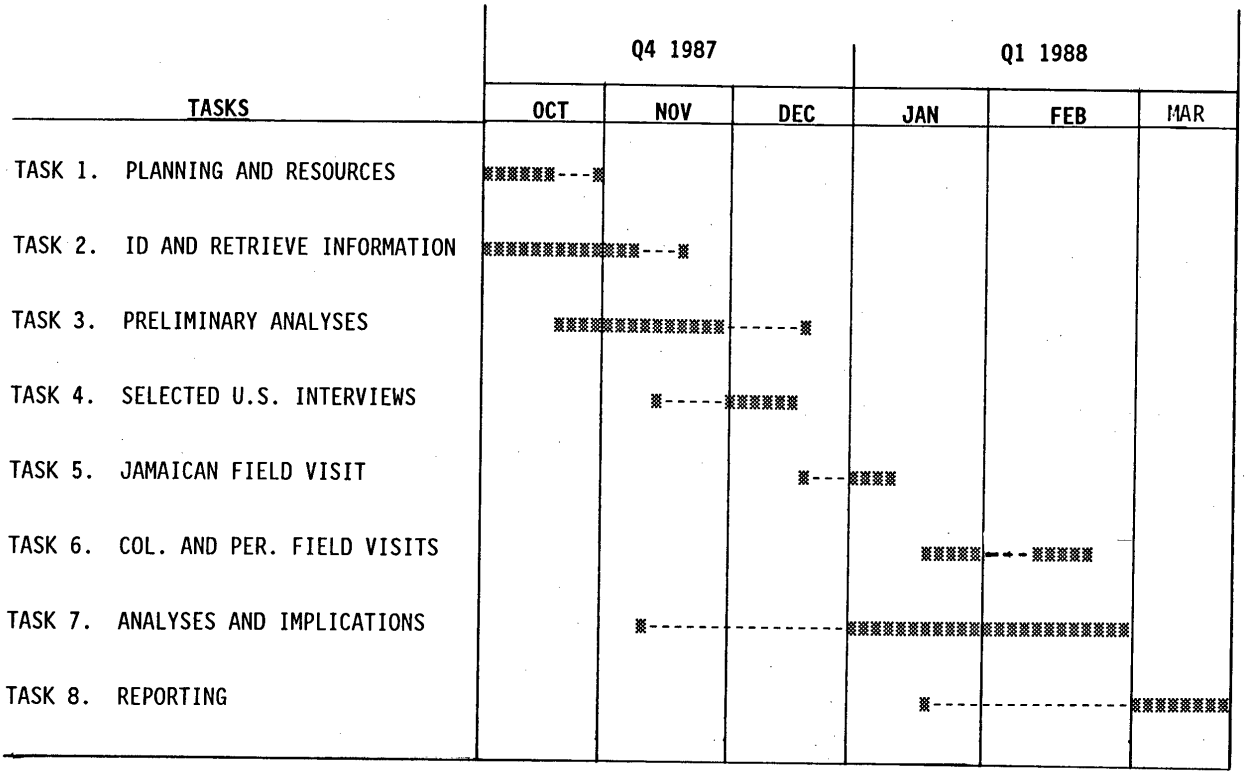
  Battelle has significant in-house capability in the production of visual aids.

PRELIMINARY SCHEDULE

Figure 5 illustrates a preliminary schedule for each of the Tasks discussed in the earlier section of this white paper. We have assumed a six-month program beginning October 1, 1987. Considerably more detailed planning with INM will be needed to finalize the schedule.

We consider this schedule achievable but very tight. Only careful attention to planning and detail will enable this program to be completed on schedule. Of particular concern are possible slippages in being able to arrange the field visits and in obtaining unpublished documents, comparisons of satellite imagery, and photographs. INM's assistance with necessary arrangements for the in-country visits is especially important.

Some attention will need to be paid to effects across seasons. We will be carrying out this program during the dry season, and will not be able to directly view immediate effects during the rainy season. Therefore, we intend to discuss seasonal effects with in-country personnel so that we present a fair over-the-year picture.



ASSUMED START DATE OF OCTOBER 1, 1987

FIGURE 5. SCHEDULE OF ACTIVITIES

INM SUPPORT

We view this program as a cooperative effort between INM and Battelle. It is essential that a solid base of communication be maintained throughout the program. Battelle can provide top-flight assistance to INM in environmental, agricultural, and economic analyses relating to this area. However, only through the tapping of INM's reservoir of staff expertise and physical assets can this program truly succeed.

In particular, we will need support through INM in the following areas:

- Provision of photos, satellite imagery, reports (from INM, DEA, and possibly other agencies), candidate in-country contacts, possibly certain INM staff expertise, and other resources relevant to this program.

- Assistance in interpreting satellite imagery and in interpreting photographs where the location, perspective, and other features are not obvious.

- The ability to obtain special analyses of satellite imagery so as to be able to isolate and/or demonstrate hypotheses and conclusions. Battelle Northwest is capable and interested in performing this function for INM. (See Appendix D for a description of Battelle Northwest's capabilities.)

- Security clearances for some of the program team members, should clearances be required.

- Assistance in travel arrangements, and in assuring that appropriate area clearances, escorts, and other protective measures are taken for the safety of the program team.

PROGRAM MANAGEMENT

This program will be managed by the Special Programs Office (SPO) under the direction of Mr. Tom Grimm, who reports directly to Dr. Frederick J. Milford, Vice President for Special Programs. The SPO will act as the Client's focal point for the program and will provide management review along with all report preparation such as monthly contract status reports, interim reports and the final contract report. Along with the Security Office, SPO acts to ensure that the spirit and letter of security regulations are followed. The SPO possesses all of the resources necessary for handling classified programs including appropriately cleared personnel, secure storage, Tempest approved computer, and a secure KY-71 telephone system.

Mr. D. Alan Scantland will be the Principal Investigator of the proposed research program. He has training in both the biological and economic sciences, has over 10 years experience in working with executive-level Clients on agriculturally oriented issues, and has strong skills in managing complex, multidisciplinary, and fast-moving programs. Mr. Scantland will be assigned to plan, direct, and schedule the research work on this program. We will be the primary contact with the Contracting Officers' technical representative on all matters related to scheduling, performance, and reporting of program research activities.

The proposed organization of the program includes participation of experienced scientists from multiple disciplines (see Figure 6). Significant involvement of the Core Team members throughout the entire program is planned. Members of the Support Team will be available when needed to participate in certain highly focused aspects of the program.

Biographical sketches of personnel selected for the program are included in Appendix A.

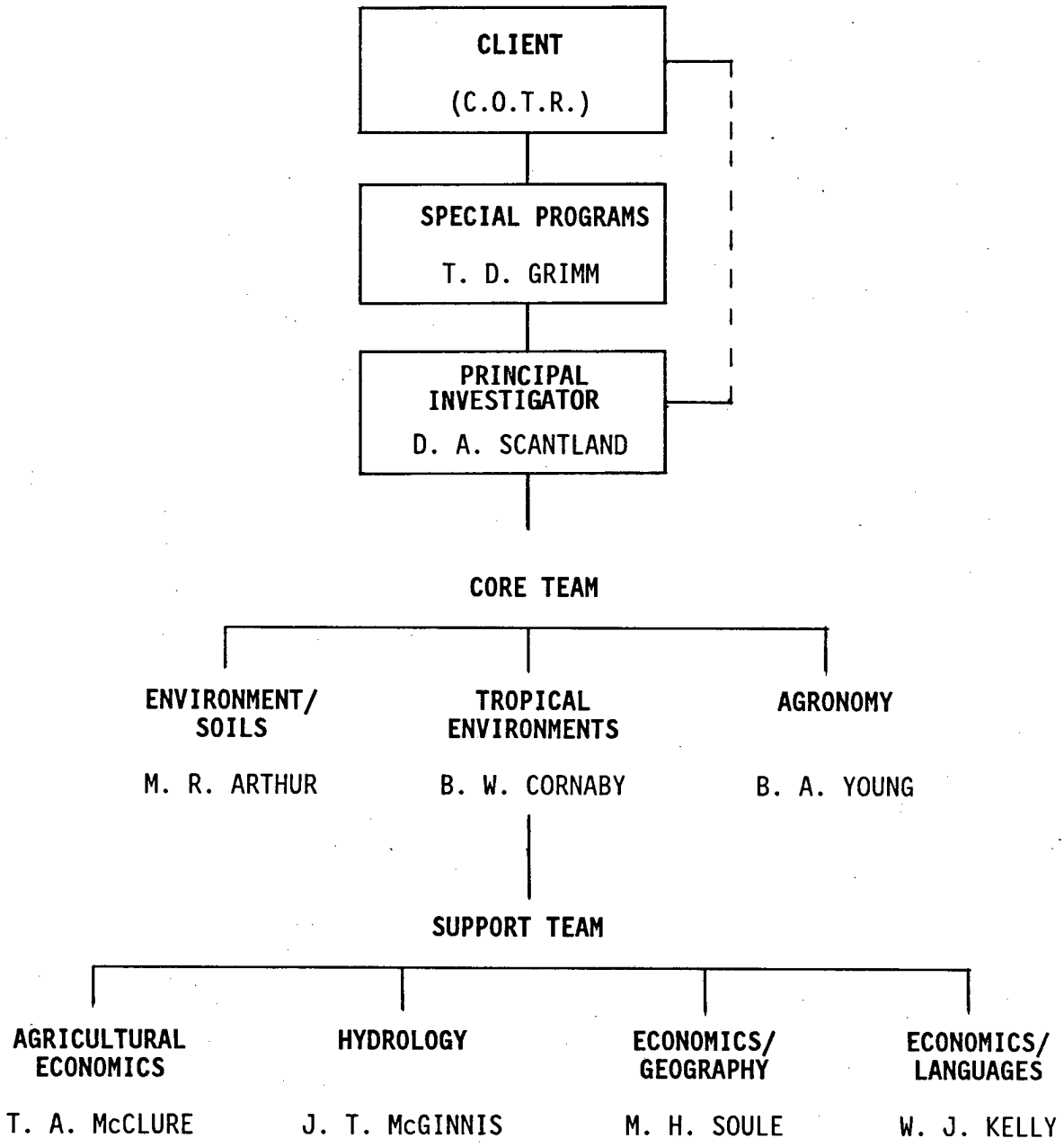


FIGURE 6. PROGRAM MANAGEMENT ORGANIZATION

RELEVANT EXPERIENCE

The Program Team has the necessary skills and experiences to carry out this program effectively*. Included within Appendix B are brief descriptions of a few programs we have conducted, and which illustrate the range of experiences which we can draw upon during this program. One or more members of the Program Team have worked on all of the Programs cited within Appendix B.

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* At the present time, only one member of the Core Team (B. W. Cornaby) holds a DoD clearance. (See Appendix A for additional clearance information.)

APPENDIX A

BIOGRAPHICAL SKETCHES

THOMAS D. GRIMM

Manager
Special Programs Office

Education

B.S., U. S. Naval Academy
B.S., Electrical Engineering, U. S. Naval Postgraduate School

Qualifications

Mr. Grimm joined the Battelle staff in 1982. As Manager of the Special Programs Office, Mr. Grimm is exclusively dedicated to and responsible for planning, administration, and management for a wide variety of research, development, and assessment efforts on behalf of Intelligence Community sponsors. In order to be responsive to the needs of the Intelligence Community, Mr. Grimm has continuous access to and interaction with all technical disciplines of Battelle Columbus Laboratories.

Prior to joining Battelle, Mr. Grimm served as a member of the Armed Forces since his graduation from the U.S. Naval Academy. As a career Naval Officer, his sea assignments were culminated by assignment as a Submarine Commanding Officer from 1972 to 1974. Following his command at sea, Captain Grimm relocated to Washington, D.C. where he spent the last 6-1/2 years of his Naval career as a Project Director in support of research and development efforts for the Director of Naval Intelligence. These programs were characterized by severe security constraints and advanced technology. As Project Director, Captain Grimm had total technical and fiscal responsibilities throughout the entire development process from initial requirements, through concept, development plan, preliminary design, critical design review, test plans, test procedures, testing, and test results. While attached to the Director of Naval Intelligence, Captain Grimm had extensive interaction with numerous national level Intelligence agencies external to DoD.

Mr. Grimm was born May 12, 1935 in Connellsville, Pennsylvania. His Social Security number is [redacted] He holds a Special Top Secret clearance granted March 25, 1983. STAT

D. ALAN SCANTLAND

Manager, Market and Technology Assessment Programs
Agricultural and Biotechnology Resources

Education

B.A., Biology, Earlham College
M.S., Agricultural Economics (Agribusiness Management), The Ohio State University

Qualifications

Mr. Scantland's background and experience enable him to apply natural scientific relationships to solve a variety of agricultural, biotechnological, biomass, and food business problems. Market structure and function, international competition, and the relationships of government regulation to business operations are important factors in research programs managed and conducted by Mr. Scantland. These capabilities have enabled him to provide significant inputs to strategy development, technology transfer and business development planning, feasibility assessment, and diversification programs for clients.

Recent Program Experience

Two example programs requiring economic analyses of agricultural businesses which Mr. Scantland has managed are cited below.

- Assessment of International Markets for Biological Plant Pesticides. This program involved a determination of future market sizes for biologically-derived pesticides targeted to specific plant diseases in four developing countries. The client, a major international agrichemical company, used the information to determine the appropriateness of embarking on a substantial R&D and product development effort. During extensive field interviewing in the countries, Battelle focused on the relative costs and benefits to growers of these products, government involvement in the local agricultural and pesticide industries, and historical pesticide consumption. In-field interviews were carried out in Thailand and Indonesia.

- Commercial Field Tests for Sweet Sorghum. As part of Battelle's major program activities to speed biomass production and utilization, we managed commercial grower field tests of sweet sorghum. Nine farmers from three states grew over 10 hectares of sweet sorghum utilizing conventional farm machinery and production practices. Three cultivars were evaluated. Analysis of the data suggested that while this heavy biomass producer could be grown with modern midwestern practices, efficiency could be enhanced substantially through more appropriate machinery.

MICKEY F. ARTHUR

Soil Agricultural Microbiologist and Soil Scientist
Environmental and Ecologic Analysis

Education

B.S., Microbiology, The Ohio State University
M.S., Immunology, The Ohio State University and The Ohio Agricultural Research and Development Center
Ph.D., Microbiology, The Ohio State University (currently)

Qualifications

Mr. Arthur has 10 years of experience at Battelle. He has conducted environmental assessments with respect to diverse agricultural systems, including effects on soils and crops due to acid deposition, power plant emissions, reservoir construction, sewage sludge application, fly ash disposal, and high-level nuclear waste isolation. All major soil types, including tropical soils, have been included in these studies.

Specific areas considered have included nutrient cycling and loss, soil fertility and erosion, crop ecology, microbiology, and soil/plant relations. For example, in one study for the U.S. EPA, Mr. Arthur led a team of researchers in the development of a quantitative model that predicts soil erosion losses in sludge-amended soils. The model is based on soil and sludge levels of phosphorus and nitrogen as the factors limiting sewage sludge application to agricultural soils.

Mr. Arthur also conducts and manages laboratory studies on soil and aquatic metabolism of pesticides, and is developing methods for in situ bioreclamation of highly polluted soils (e.g., dioxin soils).

BARNEY W. CORNABY

Sr. Research Scientist
Environmental and Ecologic Analysis

Education

M.S., Zoology/Statistics, Brigham University
Ph.D., Ecology/Entomology, University of Georgia

Qualifications

Dr. Cornaby is an expert on technical environmental assessments with 15 years experience. He has conducted/supervised ecosystem field and literature studies in the New World tropics. In Colombia and Panama he led a team on the Pan-American highway assessment in the Darien Gap. In Venezuela, his work over a three year period focused on power plant effects (chemical and physical alterations) on tropical soils, vegetation, crops, and animals. Other tropical rainforest and vegetation/ecological conversion studies, covering the period from 1938-1976, have been in Costa Rica (two months continuous) and Brazil (two times).

He has made 15 trips to Latin America including Jamaica and Peru and has given/published approximately 10 technical papers. He has a reading knowledge and conversation understanding of technical Spanish, although his true fluency is in Portuguese.

Dr. Cornaby was born on January 22, 1943 in Spanish Fork, Utah. His Social Security Number is [redacted] Cr. Cornaby holds a DoD Secret clearance. STAT

BRIAN A. YOUNG

Agricultural Biotechnology Consultant

Education

B.S., Plant Pathology, The Ohio State University
M.S., Plant Pathology, Texas A&M University
Ph.D. Agronomy (Currently), The Ohio State University

Now a doctoral student and Battelle consultant, Mr. Young was employed at Battelle through 1986.

Qualifications and Relevant Experience

Agronomic Research. Mr. Young has wide-ranging agronomic experience both at the laboratory/research and at the field/applied level. Mr. Young has a farm background giving him hands-on experience in crop production practices.

Through his association with Battelle, Mr. Young has conducted technical and economic analyses of energy crops plantations as an alternative to conventional crops. Several of these studies involved assessments of the environmental impacts of energy crop production on marginal lands. He is principal author of a reference manual on energy crop production published by the Department of Energy.

In addition to his research at Battelle, Mr. Young conducts applied research in plant genetics and breeding for the Ohio State University's Agricultural Research and Development Center.

Techno-Economic Research. Mr. Young has evaluated the potential market for a plant pesticide in four Less Developed Countries, including Brazil and Mexico. This study required in-country travel to assess both the need for the pesticide and the ability of farmers to adopt its use. In a separate study, Mr. Young evaluated the likely agronomic, social and economic impacts of over 300 "appropriate" agricultural technologies assuming they were adopted by farmers in Less Developed Countries.

In still another study, Mr. Young conducted an assessment of the world market and technical marketing obstacles for sales of a specific plant micronutrient. The world market, segmented by country, for the micronutrient product was estimated by evaluating soil micronutrient deficiencies and by assessing the likely efficacy of the micronutrient in various soils in fourteen countries.

WILLIAM J. KELLY

Principal Research Economist
Foreign Science and Technology

Education

B.A., Russian, University of Massachusetts
M.A., Economics, Rice University
Ph.D., Economics, Rice University

Qualifications

Dr. Kelly has been chosen for this effort because of: (1) his background in economic development, (2) his knowledge of Spanish, (3) his foreign travel experience, and (4) his security clearances.

Dr. Kelly specialized in economic development studies while pursuing graduate work at Rice University, studying under Professor Donald Huddle, a prominent expert on Latin America. Under Professor Huddle's supervision, Dr. Kelly wrote a doctoral dissertation on the family planning efforts of Puerto Rico. After completing his studies, Dr. Kelly taught courses in economic development at the University of Georgia.

Since joining Battelle in 1977, Dr. Kelly has been engaged in research on economic policy and R&D policy in foreign countries, including energy consumption and production, scientific and technical manpower, and technology transfer. He currently is leading a Battelle-funded study of technology transfer from the Soviet Union to Iran covering a number of types of facilities, including grain elevators.

As a result of this experience, Dr. Kelly has become familiar with information retrieval systems; data collection problems; and the techniques and problems involved in the specification, estimation, and interpretation of linear regression models.

Dr. Kelly has a reading knowledge of Russian, French, and Spanish and has been called upon by professional journals to review books published in French and Russian.

In carrying out his doctoral research, Dr. Kelly spent five months in Puerto Rico, visiting some two dozen clinics in the Northeast Health District. He also has spent time in the Bahamas, Haiti, and Mexico. During such visits, he has made a point of visiting remote villages, often traveling on local buses and "publicos".

Dr. Kelly was born in Plymouth, Massachusetts, August 24, 1942, and his Social Security Number is [redacted] Dr. Kelly holds a Special Top Secret clearance granted May 13, 1982, and also has SCI access. STAT

THOMAS A. MCCLURE

Sr. Agricultural Economist
Battelle Project Management Division

Education

Ph.D., Agricultural Economics, The Ohio State University (1972)
M.S., Agricultural Economics, The Ohio State University (1965)
B.S., Agricultural Economics, The Ohio State University (1964)

Relevant Experience

Dr. McClure has conducted and managed economic research studies at Battelle for more than 21 years. Much of his research experience has been concerned with agricultural and food-related topics. Areas of emphasis have included agricultural technology, farm production economics, marketing and financial analysis, and agricultural economic impact analysis. Since late 1984 he has contributed to economic research studies related to environmental and economic effects of disposal of spent nuclear fuel and other high level wastes. Currently he is engaged in several waste transportation topics including analysis of train accident rates, effects of human factors on nuclear waste transport safety, and development of an approach to identify routes for waste salt disposal from repository construction.

He led a 1984 Office of Nuclear Waste Isolation study, Agricultural Impacts of Siting a Nuclear Waste Repository in the Texas Panhandle. Topics addressed included a description of agricultural trends in the Texas Panhandle, repository requirements for land and water relative to agricultural use, repository impacts on agricultural production, and the issue of perceived contamination of agricultural commodities and processed food products.

Dr. McClure was project leader and principal author of The Future of United States Agriculture, 1983-2000, a one-year study for the Production Credit Association (PCA). The study described U.S. agricultural tends and regional characteristics, and focused on new technologies affecting farmers over the next two decades.

He has participated in numerous projects involving potential production of liquid fuels from sugar crops, corn, and oilseeds. He conducted an assessment of Brazil's biomass production and processing technologies. Other biomass related work has included such topics as potential for development of new crops, economic impacts on the agricultural sector, land and water availability, crop input requirements and costs, transportation and handling costs, and by-product markets.

Dr. McClure also is owner/manager of a cash-grain farm in West Central Ohio.

MASON HOWARD SOULE

Economic Geographer
Foreign Science and Technology

Education

B.A., Soviet Area Studies (1976), Kent State University
M.A., Geography (1978), Kent State University
Ph.D., Economic Geography (1982), Indiana University (candidate)

Qualifications

Mr. Soule has experience in a number of areas of direct relevance to the topic. He has taught undergraduate courses in physical geography, which included sections on soils, vegetation, hydrology, and climates. As part of his graduate work, he was engaged in fieldwork in rural areas. He also has taught college level courses focusing on problems in the developing world, and has extensive experience analyzing and interpreting maps.

Mr. Soule has taken graduate level courses in air photo interpretation and remote sensing techniques, which included analyses of multispectral satellite imagery. As part of this coursework, he worked with densitometers and wrote a paper on urban land use classification using Landsat imagery.

Prior Experience

Mr. Soule has been engaged in several studies for the U.S. Government since joining Battelle in July, 1985, mostly relating to Soviet and East European technical and economic issues. Prior to joining Battelle, he was a lecturer in the geography departments at Ohio State and Indiana Universities. He has extensive experience in applying mathematical models and computers to the study of geographical and socioeconomic problems.

Mr. Soule was born in Evanston, Illinois on June 13, 1953 and his Social Security Number is [redacted] Mr. Soule was granted a Special Secret clearance on May 14, 1986. STAT

APPENDIX B

RELEVANT EXPERIENCE

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RELEVANT EXPERIENCE

Nutrient and Radionuclide Cycling in Tropical Forests and Agricultural Lands

As a part of the feasibility study for the Atlantic-Pacific Interoceanic Canal program, an intensive study of tropical terrestrial ecosystems was undertaken. The purpose of this effort was to study the movement and storage of stable elements and radionuclides in the tropical ecosystems occurring in regions of Central America under consideration for construction of the canal utilizing nuclear devices for excavation. A major portion of this study was conducted on site in Central America. Descriptions were prepared of the terrestrial ecosystems by functional category, natural material used by man were identified, and food chains leading to these materials were identified. The spectrum of chemical elements in these ecosystems were determined by chemical analysis of various samples. Input and flow-through rates for materials were determined for significant elements of interest.

Availability of Agrotechnologies in LDCs

The objective of this project was to provide a complete study of agrotechnologies which can be expanded for use or introduced into lesser developed countries (LDC). Agrotechnologies were defined as any input, method, or equipment applicable to plants and/or animals, that will do at least one of the following: increase output; improve biological efficiency; lower production costs; decrease harvest and post-harvest/slaughter losses, and; increase shelf-life of product during processing and marketing. Technologies not yet in widespread use in LDCs, but which have the potential for adoption by these countries, were the focus for the study. Over 300 technologies were evaluated in this study.

Environmental Impact Assessment for a Power Plant on the Coast of Venezuela

This study has as its purpose to initiate an environmental impact assessment of an electric power generating facility near Punta Moron, Venezuela. The environmental impact assessment process consisted of five basic steps: (1) literature review, (2) baseline description, (3) experimental effects studies, (4) impact prediction, and (5) development of mitigative measures. Because this was the first environmental impact assessment (EIA) to be initiated in Venezuela, it was appropriate to divide the work into two phases. Phase I reviewed available data about the Punta Moron environment and possible impacts, both beneficial and detrimental, resulting from the construction and operation of the power plant. With this data the remaining steps in the assessment process could be properly planned and implemented. Thus, Phase I had as specific objectives the following:

- Conduct of literature review and evaluations to identify useful information as well as data gaps,
- Develop a study plan that could be used in Phase II to fill important data gaps, and
- Transfer of knowledge concerning the environmental impact assessment process.

Phase II, which will implement steps 2 through 5 of the EIA process, is being initiated.

Two multidisciplinary research teams, one from a firm in Venezuela (INELMECA) and a corresponding team from Battelle were created. Disciplines included four aspects of the physical, chemical, and biological environments -- air, water, terrestrial ecology, and marine ecology. The two teams worked together closely in meeting these three Phase I objectives.

Environmental and Economic Impacts of Selected Biomass Systems

In this program, Battelle examined the environmental and economic impacts associated with commercial operation of several types of biomass systems. Included systems were alcohol fuels production, anaerobic digestion, and combustion and pyrolysis.

Unfilled Market Needs for Bactericides

The principal objective of this study, commissioned by a major agrichemical firm was to determine the commercial unfilled market needs for bactericide products in four countries (Mexico, Brazil, Indonesia, and Thailand). The Battelle team travelled to each country to provide estimates of potential markets and needs for several crops. The company is using this data for its internal R&D program planning.

Commercial Grower Sweet Sorghum Field Testing

Battelle has carried out major program activities in evaluating the use of sugar crops as fuel and fiber sources. As part of this effort, Battelle managed the conduct of field tests carried out by commercial growers. Nine farmers in three midwestern states grew over 10 hectares and three cultivars of sweet sorghum as part of an effort to make commercialization efforts more effective and rapid. Agronomic and economic data was collected and analyzed over the season. One key finding was that the large volume of sweet sorghum biomass produced per unit area precluded the efficient use of typical midwestern large-scale harvesting machinery.

Evaluation of Sweet Sorghum as an Energy Crop

The objective of this project was to evaluate the yield potential of sweet sorghum in a specific west-coast location. The client was interested in establishing a biomass energy conversion facility, using sweet sorghum as a feedstock, and needed valid estimates of the commercial-scale yield likely from sweet sorghum. Battelle was asked to draw conclusions on the results of field work previously conducted by the client, and to design field experiments capable of giving valid yield estimates for the location.

Techno-Economic Evaluation of a Closed Boll Cotton Harvesting Concept

The overall objective of this research program was to perform a technical economic evaluation of a closed boll cotton harvesting system. Within this technical economic evaluation, major sub-objectives were defined:

- To develop baseline economic, cost, and energy data on the current system of cotton production and processing, from planting through mill purchase of raw cotton
- To develop similar information and data for the proposed new concept of closed boll cotton harvesting, including estimating potential cost and return data for growers and gin operators and estimating the relative increased/decreased energy consumption at these levels.
- To investigate the desirability of developing a field threshing unit to separate locks from burrs as opposed to separation at a central location (i.e., the gin yard)
- To identify any impediments to implementation of the closed boll harvesting system (such as the inability to commercially produce determinate cotton cultivars); and to suggested needed research to overcome identified impediments
- To identify desired design characteristics of a closed boll cotton harvester.

Future of U.S. Agriculture, 1983-2000

In this landmark study, Battelle identified key economic, social, environmental, and technological factors that will influence United States agriculture to the year 2000 and early into the 21st century.

The program assessed the interrelationships of potential impacts of these key factors as they may affect changes in U.S. farm production and marketing practices, farm financial management, and agricultural institutions supplying credit and other services to U.S. farmers. Agricultural production, marketing, and communication technologies were emphasized, along with their rural sociological implications. The final report contains information relative to the major commodity groups produced by U.S. farmers, and also a number of agricultural inputs such as chemicals and fertilizers, feed and animal health products, seeds, farm machinery and equipment, fuels and energy, farm labor, and capital investment and management. Historical information on the structure of U.S. agriculture, and a general review of economic trends and agricultural developments over the past two decades are covered to set the stage for the futuristic prospective.

The final report was published by Battelle Press as a book entitled Agriculture 2000 -- A Look at the Future. The study also served as a basis for selecting subject matter for a film entitled AgriAmerica, 2003 A.D. that has been shown to production credit associations, farmers and ranchers, and vocational agricultural students.

Biomass Technologies Group Program

This study:

- Identified the current and projected state-of-the-art biomass technology in selected countries, and
- Developed an up-to-date international bibliography that identified and abstracts the leading articles published on the subject

The countries selected for investigation are the United States, Canada, Sweden, West Germany, Australia/New Zealand, Japan, and Brazil. For each of the countries, an in-depth investigation is being conducted to identify the major technologies applicable to the production of fuels or chemicals from biomass (including oilseeds) and to determine the current status of biomass, problems, government's role, and other major factors influencing the use of biomass. An international literature search and extensive field interviews comprise the basic research approach. Approximately 80 industrial companies representing 12 nations participated in this program.

Management Plan for Forestry Operation on the Eglin AFB Reservation

Battelle was contracted by the Armament Division of the U.S. Air Force to demonstrate the scope of military mission requirements for Eglin AFB Reservation forest resources and to develop present and future forest management plans to meet mission requirements and incorporate forest revenue generating activities. The investigation was organized and conducted in three phases. Phase I focused on the identification of past, present, and future operational forest needs of the Department of Defense (DoD), Research, Development, Test and Evaluation (RDT&E), and training organizations using Eglin Reservation. Phase II concentrated on review of the present suitability of Eglin's forest environments to meet mission needs and initial development of a management plan to preserve the required existing forest resources and the associated natural environments. Phase III emphasized the completion of a management plan designed to, develop and maintain suitable acreages of forest environment that will better support the required present and future RDT&E, and training needs and, to incorporate revenue generating activities consistent with the primary mission. The overall plan was judged by the Armament Division to meet their current needs. An implementation schedule is being developed by the Division based on Battelle's report.

APPENDIX C

CANDIDATE (FACULTY) IN-COUNTRY INTERVIEWEES

APPENDIX C

CANDIDATE (FACULTY) IN-COUNTRY INTERVIEWEES

APPENDIX C
CANDIDATE (FACULTY)
IN-COUNTRY INTERVIEWEES

Among the individuals we will want to consider for in-country interviews are:

Jamaica:

Dean Edgar R. Thomas
College of Agriculture
Port Antonio, Portland
Jamaica

Colombia:

Alberto González Murcia
Dean of the Faculty of Forest Engineering
Universidad del Tolima
Ibagué, Tolima
Colombia

Peru:

Dr. Augusto Tovar Serpa
Dean of the Faculty of Forestry
Universidad Nacional Agraria
Lima
Peru

Ing. Dámaso Alcántara Léon
Dean of the Faculty of Forestry
Universidad Nacional del Centro del Peru
Huancayo, Junín
Peru

Ing. A. Qinteros García
Head of the Department of Agriculture and Forestry
Universidad Nacional de San Martín
Tarapoto
Peru

APPENDIX D

SUMMARY OF BATTELLE NORTHWEST CAPABILITIES AND ON-GOING RESEARCH ACTIVITIES IN REMOTE SENSING/IMAGE PROCESSING

APPENDIX D

SUMMARY OF BATTELLE NORTHWEST CAPABILITIES AND ON-GOING RESEARCH ACTIVITIES IN REMOTE SENSING/IMAGE PROCESSING

Includes:

1. Synopsis of Remote Sensing-Relevant Activities/Developments
2. Description of Relevant Facilities
   -- Remote Sensing/Calibration Laboratory
   -- Image Processing/Data Fusion Workstations

DESCRIPTION OF PACIFIC NORTHWEST LABORATORY'S REMOTE SENSING RESEARCH ACTIVITIES RELEVANT TO A DEPARTMENT OF ENERGY GLOBAL EARTH AND ENVIRONMENTAL SCIENCES INITIATIVE

SUMMARY

Since 1976 the Pacific Northwest Laboratory (PNL*) has been conducting Geoscientific Remote Sensing Research with funding from the Office of Basic Energy Sciences (OBES) Geosciences Program (Dr. George Kolstad et al.). This modest but uninterrupted basic research effort has developed advanced capabilities (facilities, hardware, software, and staff), and unique application experience associated with interactive computerized analyses of combinations of remote sensing (primarily satellite) and geoscientific (geophysical and geologic) data. These OBES developed capabilities are contributing to numerous programmatic efforts within PNL and have been the basis for several independent but closely linked remote sensing research initiatives that have since been developed within DOE (viz., OHER and Defense Programs) and via Related Services Agreements with NASA. These programs involve technical considerations such as sensor calibration, absolute radiometry, computerized quantitative analyses, and modeling functions that are directly relevant to global scientific studies that exploit satellite remote sensing possibilities. Moreover, these programs have multidisciplinary and multiorganizational (interagency) features that are basic to any serious global-scale research initiative within the earth and environmental sciences. Recent developments further document the Laboratory's interest and commitment (exploratory research funding) in fostering research that develops multidisciplinary teams and facilities for solving complex energy-related problems on local to global scales.

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* Operated for the Department of Energy by Battelle Memorial Institute

DETAILED DESCRIPTION

DOE/OBES Geoscientific Remote Sensing Task

This task has been supported by OER/OBES for over a decade to conduct basic research in remote sensing most relevant to DOE's objectives in the geoscientific area. It involves advancing the state-of-the-art in interactive image processing, computer graphics, and artificial intelligence to exploit the geoscientific potentialities of all types of remote-sensing data acquisitions (viz., visual, thermal, and microwave). The goal is to develop advanced computer techniques for processing, analyzing, and displaying combinations of remote-sensing and geoscience (geophysical and geologic) data so the geoscientists can analyze more complex data, more completely and more rapidly. This goal continues to grow in importance, as increased advancements are needed from the geosciences to help solve critical national issues associated with locating, developing, and conserving energy resources, storing waste generated during energy development, and monitoring and assessing energy-related environmental changes and trends on local, regional, continental, and global scales. Also, research conducted under this task is closely coordinated with the OBES-funded activities in aeronomy and solar research. The two current areas of emphasis involve cooperative use of the geodata (Symbolics) workstation under development and joint studies of atmospheric properties limiting the quantitative uses of remote-sensing data.

The long term OBES support has resulted in the development of a center of excellence in remote sensing at PNL. Although emphasizing geoscientific remote sensing (e.g., geoexploration and continental scientific drilling), center capabilities are becoming increasingly supportive of a variety of DOE programs within PNL (e.g., arid lands ecology, acid rain, wind energy, subsurface contaminant transport, nuclear waste repository sighting, and national security technology). Moreover, the advanced capabilities (facilities and staff) developed under this task have ben the basis for the successful implementation of several new, but closely linked, programmatic initiatives within and external to DOE. And, just recently, PNL was notified

that the "Geologic Spatial Analysis" proposal (spun off from this task) has been accepted by OBES Geosciences as a new start for FY 87.

NASA/GSFC Landsat Thematic Mapper Investigations

Since the launch of the first thematic mapper in 1982 (Landsat 4), PNL has participated as a Principal Investigator in assessing the quality and utility of satellite multispectral data due primarily to capabilities developed under the OBES remote sensing task. From 1982 to 1985 we were involved in the NASA Landsat Image Data Quality Analysis (LIDQA) Program. Currently (1985 to 1988(we are engaged in a follow-on thematic mapper radiometric calibration study. This investigation is aimed at developing analytical techniques that will enhance the scientific exploration of satellite multispectral data.

This related services research with NASA emphasizes the quantitative uses of satellite multispectral data, especially high-resolution thermal band data. It involves (1) the quantitative characterization of earth surface (land-cover) features based upon their reflectivity or emissivity at different wavelengths and their associated spectral and temporal variabilities, (2) assessment of the application potentialities of using combinations of visible and nonvisible (e.g., thermal) band, and (3) development of computerized techniques for adjusting data to account for atmospheric and sensor calibration effects.

This research is directly relevant to any global initiative in that it stresses quantitative uses, involved interdisciplinary participation (viz., remote sensing, atmospheric and ecology/hydrology specialists), and requires detailed protocols for the acquisition of supportive ground-through data. Also, through this program, we are maintaining close contact with NASA Goddard and Headquarters personnel involved in developing and implementing the Earth Observing System (EOS) being developed by NASA-NOAA specifically to foster global studies of the earth.

DOE/DP Nuclear Multispectral Data Exploitation

Beginning in 1983, and, once again based largely on capabilities developed on the OBES remote sensing task, PNL successfully implemented a series of continuing research and application programs through its National Security Technology Office. These Defense Programs' funded projects are emphasizing the development and application of advanced remote sensing and image processing techniques most relevant to DOE's national security interests. Her again, these efforts are interdisciplinary, multiorganizational (involving other DOE laboratories) and involve extensive acquisition and processing of worldwide satellite data. All of these functions are integral to any global research initiative. Of major relevance is that expense and capital equipment funds provided by DP have significantly enhanced capabilities (facilities, equipment, and staff) at PNL, as well as within other participating DOE laboratories, that can directly support a DOE role in global earth nd environment research.

DOE/OHER Support of ALE and REFLEX

Efforts were initiated in 1985 to identify technical areas within the Arid Lands Ecology (ALE) program wherein interdisciplinary activities, involving ecology, hydrology and remote sensing specialists, would offer new opportunities for substantial research advancements. Some small initial efforts began in FY 86, related mostly to acquiring familiarization with field and satellite arid land vegetation spectral data including both visible and thermal regimes. Almost simultaneously, DOE/OHER (Dr. Frank Wobber et al.) was in the process of developing a new program initiative, titled REFLEX aimed at using advanced remote sensing technologies for interdisciplinary scientific experiments involving hydrologic -- ecologic interaction. This OHER initiative provided PNL with the opportunity to more formally organize a multidisciplinary confederation aimed at developing quantitative methodologies for remotely measuring, monitoring, and modeling hydrologic-ecologic processes effected by energy developments in arid regions (REFLEX Program Plan DOE/ER-0254).

Pacific Northwest Laboratory's initial research emphasis within REFLEX is to test the possibility of combining remote measures of surface temperature with atmospheric, vegetation, and soil data to develop a computerized procedure for making landscape-level estimates of evapotranspiration in arid regions using the Hanford-ALE site as the principal study area. This experiment requires close collaborative efforts among remote sensing, hydrology, and ecology specialists to acquire and analyze digital data from field, aircraft, and satellite observations. In a broader context, REFLEX provides an ideal forum for staff from all participating DOE Laboratories (as will as several other government agencies) to share ideas, expertise, techniques, and results which individually and collectively related directly to supporting a DOE role in global earth and environmental sciences research.

Recent Developments 1986-1987

Several recent developments have occurred in the remote sensing area that will influence PNL research activities relevant to global scientific research.

- A PNL proposal for a companion basic research task to the Geoscientific Remote Sensing task entitled "Geologic Spatial Analysis" has been accepted by OBES Geosciences Program as a new start in FY 87. This task emphasizes the development of computerized geologic analysis techniques for determining spatial (Three-dimensional) relationships of earth crustal fracture planes and structural characterization. The technique involves the integration and analysis of digital data bases developed from remote sensing, mapped lithology, field measurements,a nd conventional geophysical methods. If successful, the proposed quantitative technique for determining fault, fold, and fracture orientations and locations anywhere on earth, will provide vital data relevant to US DOE concerns in energy exploration, continental scientific drilling, seismic analysis,

and waste storage sighting, as well as basic geologic mapping and tectonic studies.

- In FY 87 a major project was initiated with the US ARmy (under DOE Related Services) which also requires the collaborative participation of PNL's remote sensing and ecology/environmental staff. The objective of the project is to tailor and test remote sensing techniques for supporting environmental management functions at Army training centers such as the Yakima Firing Center adjacent to the Hanford site. The project emphasizes the development of techniques for operationally detecting and evaluating vegetation changes over the entire 400 square-mile firing center. Moreover, the project included providing PNL with an advanced interactive workstation for conducting geographic information system (GIS) type analysis with authorization for utilization on DOE projects when not engaged in Army research.
- For several years PNL's Earth and Environmental Sciences Center has been using Laboratory Exploratory Research funds to support studies involving the use of knowledge based (expert) systems for improving existing or developing new models and for a variety of small remote sensing studies involving technical issues (e.g., emissivity, microwave processing, etc.) critical to quantitative uses of multispectral data. Also, with the recent installation of a CRAY computer at Hanford, studies are in progress for evaluating pathways for linking existing image processing, data manipulation, and modeling workstations to the super station.
- Pacific Northwest Laboratory continues to explore opportunities to translate OER developed capabilities at PNL to localized applications at Hanford. The successful integration of remote sensing and ecological/environmental disciplines within several other programmatic areas has opened up new possibilities. For example, utilization of these combined capabilities for

monitoring and evaluating land surface changes associated with repository site characterization at Hanford is scheduled to commence this fiscal year.

Remote Sensing/Calibration Laboratory

In order to perform field studies and laboratory measurements in support of remote sensing data analysis, PNL personnel have established a special optical radiation/thermal calibration/testing laboratory. The purpose of this laboratory is three-fold: (1) to house temperature and optical measuring devices, such as mercury thermometers, thermocouples, and radiation temperature radiometers used in various thematic mapper/aircraft thermal calibration studies, so that the instruments can be maintained in proper working condition (calibration of all instruments against an NBS standard using consistent techniques is accomplished before and after the satellite overpass, to ensure experimental; (2) to perform experiments to investigate the effect of ground effects such as emissivity of bodies which is less than one on the temperature recording of radiometers and satellite sensors; and (3) to investigate the vapor formation effect over water on higher temperatures which give rise to temperature measurement uncertainties.

A secondary purpose of the laboratory is to provide a training ground for the collection of field data and the corrections necessary to avoid uncertainties by improper collection of field data. For example, several mechanical aspects of making measurements with field radiometers must be considered. Emitted thermal radiation can be angle-dependent. The field of view (FOV) of the radiometer must be filled, to give a correct reading that limits the distance that the radiometer is from the thermal source of a given size. The total angle of view must also be such that a uniform temperature is sensed across the area seen by the radiometer, or else the pixel phenomenon will give a "weighted temperature" reading. Finally, for field instruments that are battery-operated, the time of use in the field can partially drain the batteries and can cause reading errors unless accounted for.

Battelle Northwest currently has five computer systems dedicated to spectral and spatial data analysis. These include:

I. A UNIX-based system dedicated for Geographical Information System (GIS) work. The system is based on the Army's Geographic Resources Analysis System (GRASS) software package. The hardware configuration includes:

A MASSCOMP 5600S CPU with
- 832 x 600 x 10 color display
- 71 mg system disk
- 474 Mb Fujitsu disk drive
- 1/2' 1600 BPI tape drive
- floppy disk drive
- laser printer
- pen plotter
- ethernet port and serial ports (allowing access to other equipment in the lab)

SUN 3/50m with
- 141 Mb disk
- ethernet port and serial ports
- 1/4 tape

The SUN system acts as an intelligent windowing front end to the MASSCOMP system for the users. The SUN is also used to process GIS data in its own right when the MASSCOMP is active. Besides doing operational work the system is also used to develop new GIS functions.

II. A VMS based system for operational image processing. Hardware for this system includes:

A MicroVAX CPU with
- 16Mb of memory
- 1024 x 864 Monochrome graphics screen
- TK50 95Mb Cartridge tape drive
- 71 Mg system disk

Digitizing table
Eikonic series 850 digital camera system
Matrix film recorder
Tektronix 4125
Optical disk system for .8 Giga byte 5-1/4" cartridges
300 byte mountable disk drive
300 Mg removable winchester disk system (up to 4 drives at a time)
Graphic laser printer
1/2 1500 BPI tape drive
International Imaging System (IIS) image array processor with 17 MB of memory and 512 x 512 color monitor

Important application software on the system includes the IIS system 600 software and the LAS image processing system from NASA (currently being installed). [This system is contained in a Sensitive Compartmented Information (SCI) secure area.]

III. A R&D VMS based system for Geologic Spatial Analysis (GSA). This system uses 3-dimensional vector data (e.g., a Digital Elevation Model) or point data (e.g., seismic hypocenters) in the interpretation of geologic structures. This GSA computer system consists of:

MicroVAX cpu with
- 13 Mb of memory
- 1024 x 864 x 8 bit color graphics screen
- 95 Mb Cartridge tape drive
- 71 Mg system disk

689 mb Fujitsu super eagle
9401 tri-density 9 track magnetic tape unit
laser printer
ethernet port and serial ports (allowing access to other equipment in the lab)
24" wide Galcomp 5825 color electrostatic printer
24" x 36" digitizing table (on order)

IV. A VMS based spatial information system. This system is used for both R&D and operational activities. Software includes both in-house developed software and software "cloned" from the systems mentioned above. Of special focus for this system is the combining of different spacial data sets including vector images, vector maps, associated text information and fluid flow modeling results. The hardware for this system includes:

MicroVAX cpu with
- 16 Mb of memory
- 1024 x 864 x 4 bit color graphics screen
- 95 Mb Cartridge tape drive
- 71 Mg system disk

689 mb Fujitsu super eagle
9401 tri-density 9-track magnetic tape unit
RAMTEK 4225 (e.e., tektronic 4125 clone)
touch screen terminal
voice I/O terminal
two 380 Mb disk drives (on order)
1024 x 1024 x 29 bit color display
ethernet port (allowing access to the CRAY) optical disk system for .8 Giga byte 5-1/4" cartridges

A Symbolics-based image processing and analysis workstation that has the following components and advantages:

(a) One Giga Byte Virtual Address Space - this large virtual memory will greatly simplify programming, which is currently constrained by a 64K-byte physical memory. Large image files will appear as arrays in virtual memory.

(b) Higher Computational Rates - the floating point computation speed is two to three times greater on the new system.

(c) 1280 by 1024 Pixel Color Display - the high-resolution color display frame buffer appears as part of the virtual memory of the Symbolics system. This feature considerably simplified the creation of complex dynamic displays.

(d) State-of-the-Art Users' Interface - the system has a highly interactive program development environment. This environment makes editing, testing, and debugging of programs much faster.

(e) Hardware designed for the LISP Computer Language - the computer hardware has been designed specifically to run LISP efficiently. The system will execute LISP programs several times faster than the VAX 11/780.

(f) LISP and FORTRAN Can Be Mixed - this feature means that existing software in FORTRAN can run on the system with additions made in LISP.

(g) Utility of Expert Systems and Other Artificial Intelligence Applications - this system is basically an AI workstation. It runs LISP, the preferred language for artificial intelligence applications in the United States. These features open many possibilities for improvement of existing software and development of new software that do not exist on the current minicomputer.

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