THE ENVIRONMENTAL IMPACT OF ILLICIT NARCOTICS CULTIVATION

Prepared by

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

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A Proposal Prepared For:

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EXECUTIVE SUMMARY

Foreign governments need additional incentives to control or eradicate illicit narcotic crops cultivation and production. In consideration of environmental damage to the foreign natural resources, and resultant social and economic impacts, the scientific approach and methods to measure consequent undesirable environmental changes can be utilized, particularly regarding results from clear cutting of tropical rainforests to grow illicit drug crops.

A multidisciplinary team of experienced environmental specialists will provide the expertise in integrated disciplines. These include soil science-fertility, aerial photointerpretation, remote sensing and geographic information systems, meteorology and climatology, water quality and hydrology, forest and plant ecology, and computerized management information systems for data base searches, storage and retrieval analysis.

Objectives are presented for both short (6 month) and long-term (5 years) studies with quality controls for the respective operational areas, along with approaches, methods and anticipated results. A preliminary literature review, obtained from a search of pertinent data bases is given. Resumes of multidisciplinary in-house team personnel are briefly listed. LEMSCO-Las Vegas Environmental Program Office's capability and commitment to the proposed project are summarized. Lockheed Corporation's resources are available for support purposes.

INTRODUCTION

The United States is unable to stem the entrance of illicit narcotics from Caribbean and Latin American sources. Despite the illegality of cultivation and the possible foreign prosecution of growers, the lucrative cash returns outweigh any concern resulting from natural resource damage and other environmental impacts. The unwillingness or inability of foreign sources to prevent or control cultivation of illicit narcotics requires various inducements or alternatives to the present attempts to curtail this production.

One approach is to provide foreign governments, under social, economic, and population pressures, with scientific data on the natural resource and environmental damage to ecosystems incurred by uncontrolled growth of illicit narcotics. Although such environmental damage may or may not be immediately apparent, in the long-term, such effects will only exacerbate the country's social and economic problems through loss of natural resources, such as tropical forests, fauna, soil, water quality, and habitat. The scientific approach to this problem, with the presentation of hard data, may provide United States policy makers with the "ammunition" needed to induce foreign governments to cooperate in specific anti-narcotics programs.

The scientific method proposed here is to review the literature, both data bases and local reports, and to coordinate remote sensing with actual field and laboratory investigations to (1) determine the history and spread or increase in illicit narcotics cultivation, (2) determine the present status and environmental effects of illicit narcotics cultivation, (3) present needs/recommendations for further study to enhance scientific objectives regarding environmental impacts, (4) provide scientific data usable for approach to foreign governments, and with recommended courses of action to curtail or eliminate illicit cultivation and production or narcotics, and (5) present foreign governments with alternatives and a risk analysis to include potential social and economic consequences of inaction or inappropriate actions. Various scientific disciplines are needed to obtain the desired information.

We propose to bring together a team of in-house specialists (Appendix A) in soil science, aerial photointerpretation, remote sensing and geographic information systems, meteorology and climatology, water quality and hydrology, and forest and plant ecology. They will provide expertise to guide this study through the statement of research objectives, technical approach, and scientific methodology. If in-house personnel are not available to fully participate, or if a specialty is required that we presently do not have, we will identify the necessary specialist and sub-contract portions of the assignment to them, including Lockheed Corporation resources. The anticipated results provided by this multidisciplinary team will be based upon the actual field situations, and will provide scientific data, and information that can be understood and used by foreign government leaders to stem illicit narcotic cultivation and control ecological damage. This information will quantify environmental effects on tropical rainforests and resources. We anticipate the information will provide United States policy makers with sufficient scientific data on environmental damage to obtain foreign cooperation to control or eliminate illicit narcotics cultivation.

OBJECTIVES

Short Term, Initial 6 month period

- o Determine the observational effects of illicit narcotics cultivation on soil fertility, exacerbating chemical processes, mechanisms, transport, rate, and fate of soil nutrients.

- o Locate, document, and characterize areas of illicit narcotics cultivation and associated environmental effects by using historical and recently acquired aerial photography.

- o Document, using existing data, that clear cutting of tropical rainforests is having adverse effects on water quality and natural rate of erosion processes.

- o Determine and compare preliminary biomass variations and plant nutrient loss between natural forest ecosystems and drug crop-cultivated areas.

- o Spectrally classify and characterize areas of illicit crop cultivation using satellite-acquired image data from the Landsat multispectral scanner (MSS) and Thematic Mapper (TM); perform change detection studies to quantify environmental impact in terms of tropical forest reduction or loss; plan for integrated environmental analysis using geographic information systems (GIS).

Long Term, Subsequent 5 years

- o Perform integrated environmental analysis of multidiscipline data sets using geographic information systems for identified areas.

- o Define specific ecosystem changes by applying and developing a variety of indices describing forest diversity, evenness, and biomass.

- o Characterize spectral response patterns from satellite image data over areas of illicit drug crop cultivation.

- o Determine and characterize the impacts of illicit drug-related deforestation on meteorology and climatology and identify any associated economic impacts.

- o Develop characteristic aerial photointerpretive and photomorphological indicators for illicit narcotics cultivation; ascertain optimum film/filter/scale combinations for target detection; investigate photointerpretation opportunities using advanced sensor data such as airborne radar and stereoscopic imagery from the SPOT satellite.

- o Document clear cutting effects relative to a pristine basin, the length of a river impacted by erosion, seasonal variation of erosion effects, and potential effects on local fisheries. (A longer-term second phase would involve monitoring the field sites through several cycles to document the effects of clear cutting or the increased rate of clear cutting).

- o Develop temporary or nondestructive soil nutritive chemical alterations, in conjunction with bioengineered microorganisms, to eradicate and/or control growth of drug-related crops.

BACKGROUND

Soil Ecosystem Effects

Coca has been cultivated in Caribbean and Latin countries by the Indian, Black, and Mestizo populations for hundreds of years, and both coca (*Erythroxylon coca*) and marijuana (*Cannabis sativa*) are now grown as lucrative illicit cash crops. Their extension into tropical rain forests has both short and long-term environmental impacts, as well as social, cultural, and economic effects. As more and more rainforests are destroyed to grow these crops, one of the environmental effects pertains to soil fertility and associated soil ecosystem phenomena, such as destruction of ground cover and soil organic matter, depletion or loss of soil nutrients, alteration of soil structure, increased weathering and oxidation of soil minerals, promotion of soil toxicity, and acceleration of soil erosion either through poor management or mismanagement of the plant and soil ecosystem. Soil erosion not only destroys or depletes the soil of its essential physical and chemical properties, but exacerbates environmental effects on other ecosystems through the products of erosion, such as siltation and eutrophication of streams, rivers, lakes, floodplains, and coastal areas.

Loss of plant nutrients and other chemical elements from soil is a natural and continuous phenomenon. These losses occur through the processes of leaching, volatilization, surface runoff, and erosion, operating individually or collectively. Accurate, quantitative measurements of nutrient losses from soils, even under natural field conditions, are difficult to measure. Because water is the principal transporting agent of most nutrients, quantitative loss studies involve the measurement and continuous sampling of runoff and drainage waters. These leaching losses are commonly determined largely through the use of lysimeters and by the analysis of waters at discharge points. Usually field plots are statistically designed, established, and used to measure runoff nutrient and erosion losses.

The nutrients most vulnerable to losses are nitrogen (N), potassium (K), calcium (Ca), magnesium (Mg) and sulfur (S). Nitrate (NO_3^-) is highly mobile and is readily transported by water, as are soluble sulfates (SO_4^{2-}), although nitrogen and possibly sulfur are also lost by volatilization. Leaching losses of phosphorus (P) can be appreciable in rich, organic, tropical soils. High amounts of all potentially available nutrients are lost by soil erosion. Losses of nitrogen from stable forested land are generally low, but deforestation greatly accelerates this loss. Erosion can account for large losses of sulfur. Very few studies have been conducted on micronutrient losses by leaching or runoff in any soil ecosystem, but these would be important in understanding soil nutrition, soil/plant chemical balance, and resultant control of crop growth and productivity.

Aerial Photointerpretation

Aerial photointerpretation is a well developed and well documented technique for a variety of vegetative discrimination applications. The location and identification of drug crops may be viewed as an outgrowth of land use/land cover and vegetation mapping. In addition to simple drug crop identification, some prominent associated environmental effects can be clearly documented on aerial imagery. These may include physical evidence of erosion and runoff, agricultural to drug crop conversion, estimates of forest acreage loss, surface water impacts, and deposition effects on sensitive resource areas such as adjacent wetlands, parks or preserves, and habitats.

One of the most powerful and useful capabilities of aerial photointerpretation can be detection of temporal changes. Archival imagery can be assembled in chronological data sets, analyzed, and exhibited to show detailed and generalized environmental trends. For detailed analysis over small areas, large scale imagery is used. In addition to the documentation of physical removal and loss of the tropical forest resource, physical removal or storage of the key indicators of illicit activity such as shacks, sheds, trails, roads, smoke plumes, and harvested product may also be detected. Over larger areas, small-scale imagery is used to examine regional environmental effects, including areal extent of deforestation, trends in the direction and intensity of resource loss, conversion of the agricultural-to-drug crop base, and effects of watershed, sedimentation, and associated downstream phenomena.

Meteorological and Climatological Effects

The environmental impacts of deforestation on meteorology and climatology involve a variety of lesser or greater magnitudes and scales of time and areal extent. On the micro scale (less than 100 meters) there is little doubt that deforestation creates significant changes in the micrometeorology and microclimatology. The general influences of vegetative cover on temperatures, humidity, winds, gas exchange, radiative and dynamic transfer processes, and the soil and hydrologic cycles are discussed extensively in the literature. While field studies can document the specific changes at a given site, the ability to extrapolate these results to other sites, or to generalize for all sites, is limited by the complexity of the meteorological, microclimatic, and climatological factors involved, and the influences of large scale processes.

The ability to assess the impacts at larger scales is even more difficult. A single site probably has little measurable impact on the mesoscale (100 m to 100 km) or the synoptic scale (greater than 100 km). However, the cumulative impact of many sites may significantly impact large scale processes. Unfortunately, most of these impact projects are based largely on computer models. These models often produce conflicting results and are not universally accepted.

It is unlikely that the published research deals with the specific problems addressed by this study. However, the literature probably provides much of the "generic" information required to address these issues. This information needs to be applied to the selected case studies.

Water Quality Effects

The process of clear-cutting forests has been shown to create several adverse effects on water quality. These effects can largely result from the higher concentrations of suspended solids as a consequence of increased erosion. As summarized in Table 1, these environmental impacts can potentially manifest themselves in terms of physical, biological, or chemical effects. Because of the remote areas in which the clear cutting is occurring, the principal expected effects of higher rates of erosion would be an intensified rate and concentration of suspended solids, turbidity, and subsequent deposition. Specifically, the most likely effects would be a reduction of photosynthesis that could alter the aquatic food chain, a reduction in populations of food organisms necessary to support fish populations, and possible disruption of fish spawning cycles. Depending on the solubility of chemicals associated with the eroded soils, increased concentrations of major cations, major anions, and total dissolved solids might become apparent. Also, unexpected conditions could occur which might be difficult to relate to erosion, these would be higher concentration of heavy metals or exotic chemicals and/or direct mortality of the fish population. Therefore, these processes and effects on the aquatic ecosystem in relation to illicit drug crops, would need to be studied and analyzed.

Table 1
Potential Effects of Suspended Solids on Water Quality

Physical Effects

1. Unaesthetic turbidity increases.
2. Physical impairment of photosynthesis.
3. Deposition of transported solids.

Biological Effects

1. Reduction of spawning grounds.
2. Reduction of organisms in the food chain necessary to support fish populations.

(continued)

Table 1. (continued)

3. Toxicity of suspended solids to several forms of aquatic life.
4. Stimulation of algal growth and eutrophication.
5. Stimulation of bacterial, protozoan, and other microaquatic growth and populations.

Chemical Effects

1. Promotion of chemical imbalances.
2. Increases in heavy metals and micronutrient concentrations due to dissolution.
3. Increases in phosphate, sulfate, and nitrate concentrations.
4. Increases in total dissolved solids concentrations.

Forest Ecology

The forces giving rise to the wholescale destruction of the earth's most productive areas are virtually all driven by economics, and the local inhabitants desiring to obtain the highest cash return for crops produced. To meet the economic necessities of expanding (and exploding populations), vast areas of tropical rainforest are being cleared yearly to provide homes, farms and industry.

The tropical rainforests exist in relatively poor soils. To survive, the earth's rainforests need an uninterrupted, functioning complex series of biogeochemical cycles in which nutrients are moved from the soil to the plants and animals, and then as remains, back to the soil to start the cycle over again. Removal of native plants from an area destroys the primary functional aspect of that ecosystem. Once altered, an area may never reestablish its original endemic components of interdependent plants and animals.

Digital Remote Sensing and Geographic Information Systems

Remote sensing digital analysis offers one means of assessing deforestation problems. Its synoptic view and capability for temporal analysis make it a valuable tool for monitoring changes due to deforestation. Furthermore, these changes can be quantified using digital analysis of high resolution data.

Satellite systems, such as Landsat and SPOT, offer high resolution multispectral data for nearly all areas of the world. Five Landsat satellites have been collecting data nearly continuously since 1972; one SPOT satellite has been collecting data since 1986. Orbital characteristics of these satellites enable them to repetitively collect data over the same point on the ground. This repeat cycle varies between 3 and 18 days, depending on the satellite system. The spatial and spectral resolution of the data collected by these satellites vary with the sensor used. Spatial resolution ranges between 10 and 20 meters, while spectral resolution is expressed in a variety of bandwidths ranging from blue reflected energy to thermal infrared energy.

Nearly all data collected for the studies, whether they are derived from remote sensing, field sampling, existing tabular or mapped information, or other sources, will have spatial components, *i.e.*, locational attributes that relate the data to some earth coordinate system. As these data are collected for the studies, they can be entered as individual layers into the geographic information system (GIS). A GIS is an efficient, computer-based system for managing, analyzing, and displaying spatial information. Data of varying scales can be entered because the system has the capability to relate the various layers to each other on the basis of their locational attributes. The result will be an integrated system of spatially-related information, rather than merely an assemblage of separate pieces of data. In this way, data from diverse sources can be efficiently managed by the GIS.

We will use the GIS to integrate the various types of data collected for the study sites. Data within this system can be analyzed in various combinations, potentially yielding new information from that originally collected. This new information can be used to supplement existing data in the decision making process for environmental effects of illicit drug crop cultivation and production.

We propose the use of a GIS primarily as a long term data management tool. This long term aspect is necessary because data will be entered into the system upon collection and will take place throughout the duration of the project. This will leave little time to assemble the data base for all collected data and perform subsequent GIS analysis of the project, but in the short term, it will be possible, however, to begin building the data base within the limited time frame of the initial project. Those data collected in the early stages of the project can be entered into the system, with other data to follow as it is collected. In this way, the GIS would evolve with the data, managing existing data as it is made available.

Another digital image processing technique which may prove to be useful for this study is the merging of multiresolution remote sensing data. An example application of this technique is the merging of 20-m resolution SPOT multispectral data with 10-m resolution SPOT panchromatic data. The technique has been shown to sharpen the 20-m multispectral images thereby enhancing their interpretability. This technique has also been successfully applied using other data sources.

APPROACH

Soil Ecosystem Effects

The nature of the proposed study (*i.e.*, illicit drug crop cultivation) and the initial short term tenure of the study (six months) precludes the standard, controlled, field plot studies, especially in the setting up of lysimeters to measure particle and nutrient transport, loss, and the minimal use of controls (*i.e.*, long term comparison with undisturbed forests and legitimate agricultural crops). It is proposed, therefore, that the initial soils ecosystem study be designed and organized for (1) initial field observations, (2) field measurements with portable supplies and field test equipment, (3) procurement of statistically valid (if possible) field samples, and (4) laboratory analysis and interpretation of results.

The initial procedure would include a literature review for regional tropical soil characteristics, soil fertility, natural vegetation characteristics, and both legitimate and illicit crop growth requirements and production. A determination would be made of possible knowledgeable native resources--professionals, individuals, universities, etc.--and subsequent contacts made for information and cooperative purposes. Subsequently, selections would be made for field studies, procurement of soil samples, laboratory analysis, and interpretation of preliminary results.

Aerial Photointerpretation

A key component of the photointerpretation study will be determination of the available existing imagery in the areas of interest, and its suitability for characterizing areas of illicit narcotics cultivation. Among the considerations for the imagery will be photographic scale, acquisition date, film type (natural color, infrared color, black-and-white), film format, photographic quality (cloud cover, sharpness, processing), and completeness of coverage. Once the status of all available imagery is established, a detailed analysis plan will be developed and implemented to fully exploit the information contained in the aerial photographic data.

Meteorological and Climatological Effects

In the short period available to perform this research, a search of existing literature pertinent to the geographical region will be performed. Current on-going research will be identified and incorporated, and an interpretative report addressing the environmental impacts will be prepared; subsequent research needs will be defined; and, a program of on-going research will be developed to include study sites in each region.

Water Quality Effects

The consequences of increased erosion will vary seasonally, with the greatest effects occurring during or shortly after the fall rainy season. Since this may not occur within the six month performance period, and some of the effects such as fish spawning reduction could take years to document, a two-phase approach can be considered. The first phase would consist of compiling historical information on the aquatic systems of interest. The purpose is to determine (1) how much information is already available, (2) how much additional information will be required, (3) if there are already indications of water quality changes over time, and (4) if there are any significant species of commercial fish that could be impacted by increased erosion. Depending on the basin or watershed to be studied, an appropriate long-term field monitoring program would be developed to complement existing data and assess the impact of increased erosion on water quality. Under ideal conditions, a controlled monitoring program would be established in the pristine basin, and in an experimental basin undergoing clear-cutting for comparison purposes.

Forest Ecology

A comparative study will be made between natural and undisturbed forests and disturbed areas, totaling 16 areas. Four sampling areas will be established in undisturbed forest. Four more will be established in areas with standing crops of illicit plant material. A third four sampling area will be set up on land with a post cultivation status, regardless of crop species. A final four study plots will be set up in fields under cultivation for food crops.

Field sampling will require compilation of species censuses for the major groups of plants and animals, as well as determination of the microbiological components of those ecological systems.

Digital Remote Sensing

Remote sensing digital analysis techniques will be used to assess the areal extent of tropical rainforest deforestation, specifically as it applies to the cultivation of illegal narcotics. This is important because the destruction of tropical forest ecosystems has severe negative impacts upon the environment.

Digital analysis techniques of high resolution data will be applied to assess land cover characteristics for each of three study areas. Satellite data will be classified into land cover categories, focusing on agricultural and forested land. The analyses will use multiple date satellite data to ascertain changes and a quantified estimate of land use, land cover over time, and forest lost to other land uses. Spectral analyses will also be performed in an attempt to identify those lands specifically used for the cultivation of illegal narcotics. This information can then be used to determine the extent of deforestation caused by this activity.

Additional analyses of these data will involve geometrically correcting the data to an earth coordinate system. This will enable land use changes to be expressed in quantifiable units such as hectares or acres. These results will be graphically portrayed on computer generated plots and overlayed onto maps, showing the extent of changes and where they have occurred.

METHODS

Soil Ecosystems

Field work includes soil sampling and use of easily portable test equipment to collect soil samples and to semi-quantitatively characterize samples in the field. Field sampling includes procurement of samples for physical, chemical, and possible mineralogical and microbiological analyses, according to modified soil conservation service procedures.

In situ semi-quantitative analyses are performed with portable soil test kits. These field analyses include soil reactivity (pH) and selected nutritive cations and anions, such as nitrate, nitrite, ammonia, phosphorus, sulfate, iron, aluminum, calcium, magnesium, potassium, zinc, chloride, and molybdenum. Laboratory analyses include tests for moisture, bulk density, porosity, texture, cation and anion exchange capacity, exchangable acidity, sulfate adsorption and specific surface, total nitrogen and total carbon, and possibly other laboratory "retests" to obtain more desirable quantitative data.

It is expected that local professionals or technicians could be trained in a short time in the use of the soil test kits, and to assist in the interpretation of results as affected by local environmental factors. Local personnel also could be trained to obtain data or information on a periodic or extended time basis during seasonal changes.

Aerial Photointerpretation

- *Principles of Analysis*

  Stereoscopy is the basis of aerial photographic analysis. Photography is acquired as a series of overlapping frames along a predetermined ground track. The aerial film is viewed through a special instrument that optically reconstructs the ground scene in three dimensional detail. Features thus observed can be identified on the basis of color, texture, size, shape, location, context, and association. The scene is then characterized based on expert knowledge. An aerial photointerpretation code may be used to label features in aerial scenes of high complexity or size.

- *Measurement Design*

  Accurate delineation of the area to be photographed will determine other considerations such as camera focal length, camera format size, average elevation of study area, and desired overlap and sidelap. In addition, environmental information will be accounted for, such as growing season, cloud cover, sun glint avoidance, and solar elevation.

- *Photographic Scale and Resolution*

  The two main variables in planning photographic data acquisition are scale and resolution. The larger the photographic scale, the higher the resolution (visible detail in the aerial scene). However, a large photographic scale requires more exposure to cover a given area consequently. Balance must be drawn between study area size(s) (number of exposures) and feature(s) of interest size (resolution). Once an acceptable balance is obtained, development of a photo acquisition plan can be completed.

- o *Quality Control and Assurance*

  Quality control and quality assurance checks are performed in all phases of aerial photography projects. These are summarized below:

Planning Phase	1) define data requirements 2) design project flight plan 3) define additional auxiliary data requirements
Data Acquisition Phase	4) undertake pre-mission briefing
Data Reduction and Processing	5) screen of film data 6) verify auxiliary data against project specifications
Data Analysis	7) standardize image analysis references 8) screen analysis for completeness and data requirements 9) independently verify with in-field personnel, site visit, or third independent analyst
Final Documentation	10) review technical report draft 11) obtain all final approvals 12) publish report

Measurement

Analysis of aerial film includes a variety of techniques to transform the data contained in the images into useful information:

- o Image interpretation

  Spectral analysis
  Spatial analysis
  Stereoscopic analysis
  Monoscopic analysis

- o Image mensuration

- o Statistical analysis

- o Digitizing of data

Meteorology and Climatology

To adequately address the meteorological and climatological impacts of illicit drug cultivation, a literature search will be performed and a bibliography will be compiled on meteorological and climatological factors favorable or necessary for plant growth. Based on the search, major publications on deforestation in Latin America and related areas will be reviewed, and additional relevant publications on deforestation will be identified. This review process will also serve to identify existing experts in this and related fields. Additional information and inputs will be solicited from these experts. Also, preliminary findings from on-going research activities will be solicited. The results of this process will be summarized and interpreted as they relate to illicit drug cultivation and deforestation in the three case study areas. These results will then be incorporated into a series of final reports addressing the integrated short term and long term environmental and economic impacts of these activities.

In addition to the interpretive report, a long term research plan will be developed based on identified deficiencies in the current knowledge base. These research initiatives will address specific areas of applied research that are required to strengthen or extend the conclusions reached in the final reports.

Water Quality

The field monitoring will initially focus on major aquatic constituents such as calcium, magnesium, electrical conductivity, dissolved oxygen, turbidity, and nitrate. These parameters will receive attention because they are expected to change as a consequence of erosion.

Each of the determined parameters can be determined immediately in the field by using Hach kit field test methods and portable battery operated instruments. This approach would alleviate the logistical problem of handling and storing samples collected in remote locations. Selection of initial study sites will be in coordination with the other field efforts.

In consideration of remote sensing data, development of aquatic ecosystem relationships could show the benefits of long term remote monitoring of aquatic ecosystem changes.

Forest Ecology

The initial methodologies will consist of establishing three sample areas within native forest and another three within standing crops of narcotic plants. Soils beneath canopy will be replicate sampled with a coring tool at 10, 70, and 30 cm depths. Total carbon and soil nutrients relative to plant analyses will be determined from those samples, and plant total biomass will be determined along replicate vertical and horizontal transects in both crop and natural areas using forestry sampling techniques. Representative leaf and wood samples will be taken and analyzed for nutrients and total carbon. Biomass will be expressed as mass per unit area (10 g/m--ultimately as kg/hectare).

Digital Remote Sensing

Digital analysis of land cover will be performed using a supervised classification technique. This requires that training sets must first be taken to characterize the spectral response of resources to be mapped. Determination of training set areas will be made from field visitation of the study sites, and from interpretation of aerial photographs. A statistical analysis of the training sets will be used to computerize group areas of spectral similarity. In this manner, a land use classification will be achieved for each of the three study sites.

The resultant classification procedure will be used to analyze multiple dates of satellite data for each site. Classifications produced for each date will be compared to determine changes in forest resources that have occurred over time. This analysis will provide for the calculation of the area of forested lands lost to other land uses.

It is anticipated that much of the loss of forested lands can be attributed to the increases in the cultivation of illegal narcotics. To verify this theory, we will attempt to determine the areal extent of this illegal activity. This will be facilitated if we can successfully characterize the spectral response of marijuana and coca plants.

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ANTICIPATED RESULTS

Soil Ecosystems

As an initial, cursory survey, it is expected that the soil ecosystems and certain soil characteristics, *e.g.*, structure and essential soil nutrients, will reflect a decrease in soil fertility and associated adverse environmental effects due to narcotics production. It is expected that this brief survey will provide guidance for further studies of a more detailed and scientific nature to partially meet short term objectives. Depending upon future studies, it is expected that temporary soil chemical manipulations, and/or in association with bioengineered microorganisms, can drastically affect illicit narcotics crop germination, growth, development, maturity, and production, both qualitatively and quantitatively, *e.g.*, induced chlorosis and nitrogen imbalance, thereby reducing the quality and quantity of the crops, and promoting disease susceptibility by insect or microbial vectors. If desired, application of nontoxic soil-plant growth substance and inhibitors can be determined for temporary effects, and residuals flushed from the soil ecosystem during successive rainy periods as demonstrated in trial field study plots.

Aerial Photointerpretation

Preparation and presentation of final project documentation includes a technical narrative of on-site observations and graphic illustrations, including photographic, photomosaic, and map overlays. Additionally, tables summarizing the results of image mensuration and statistical analysis can also be included.

Results should clearly document and characterize trends in tropical rainforest deforestation subject to illicit narcotics cultivation. Analysis of newly acquired aerial data (summer, 1987) should provide up-to-date information on recent cultivation incursions into the rainforest. In addition, aerial photography should provide an important verification tool for satellite imagery using the Landsat MSS (multispectral scanner) and TM (thematic mapper) sensors.

Meteorology and Climatology

It is expected that this study will provide the following results:

Bibliography of meteorological and climatological impacts of deforestation and illicit drug cultivation.

Summary of current research relative to deforestation and illicit drug cultivation.

Interpretive summary of meteorological and climatological impacts.

Integrated assessment of the environmental impacts in the case study areas.

Water Quality

The short term effort will focus on the possibility of using existing data to document that clear cutting is having an impact on water quality. This will depend on the basin selected, the intensity of historical sampling completed, and the level of clear cutting that has occurred in the basin.

It is anticipated that longer term monitoring results will document the effects of clear cutting relative to a pristine basin, the length of an aquatic system (river) that is impacted by erosion, the time of year that erosional effects would be expected, and a summary of the potential effects on local fisheries.

Additionally, it is expected that the potential effects of increased erosion would also increase the need for any necessary navigational dredging. While this effect would not be significant in many streams, it could be important if the clear-cutting occurs along the upstream reaches of major rivers that flow past or through population centers. The consequences of increased dredging and dredged material disposal due to silting from increased erosion will be addressed, if it is appropriate for the study basin selected.

Forest Ecology

Analysis and comparison of total carbon and nutrient values within the soil-plant ecosystem will give insight into the depletion and removal of carbon and associated nutrients by growth of narcotic plants. Changes in carbon values will also provide indications of forest soil microbial populations, *e.g.*, mycological and bacteriological components of the soil resulting from removal of native plants, and hence the raw material of decay and recycling of decay products. It is expected that the most dramatic results will arise from analyses of values for plant bound nutrients and total carbon when the native and cultivated areas are compared. The lesser amounts of total carbon and nutrients from that portion of the ecosystem that has been cleared for cultivation can be expressed as a direct loss of natural resources.

Digital Remote Sensing

The results of these analyses will be presented using two forms of output, tabular summaries and computer generated maps. Tabular listings will be produced which summarize the areal extent of land use changes related to deforestation and illegal drug cropping activities. Computer generated maps will be produced from a color electrostatic plotter. These plots will overlay existing base maps and will graphically portray changes in land use over time. An example of one our output products is present on the following page. This, for example, is how we used Landsat digital data in the GIS to analyze an intensive agricultural area in Ohio where excessive precipitation run-off caused accelerated erosion, and a consequent reduction of local surface water quality of rivers and lakes.

LEMSCO produced a series of photo maps such as the one shown where crop residue left on harvested agricultural fields was automatically identified within the GIS and graphically discriminated on the rectified photo crop output. The GIS merged ground observations and geographically correct coordinates in the GIS with the classified MSS digital data to produce color code photo map products such as the one illustrated. The importance of this experience is that it allows LEMSCO to support INM with a powerful analysis and interactive graphics tool to manage environmental monitoring data, and to assist in the environmental assessment decision making process.

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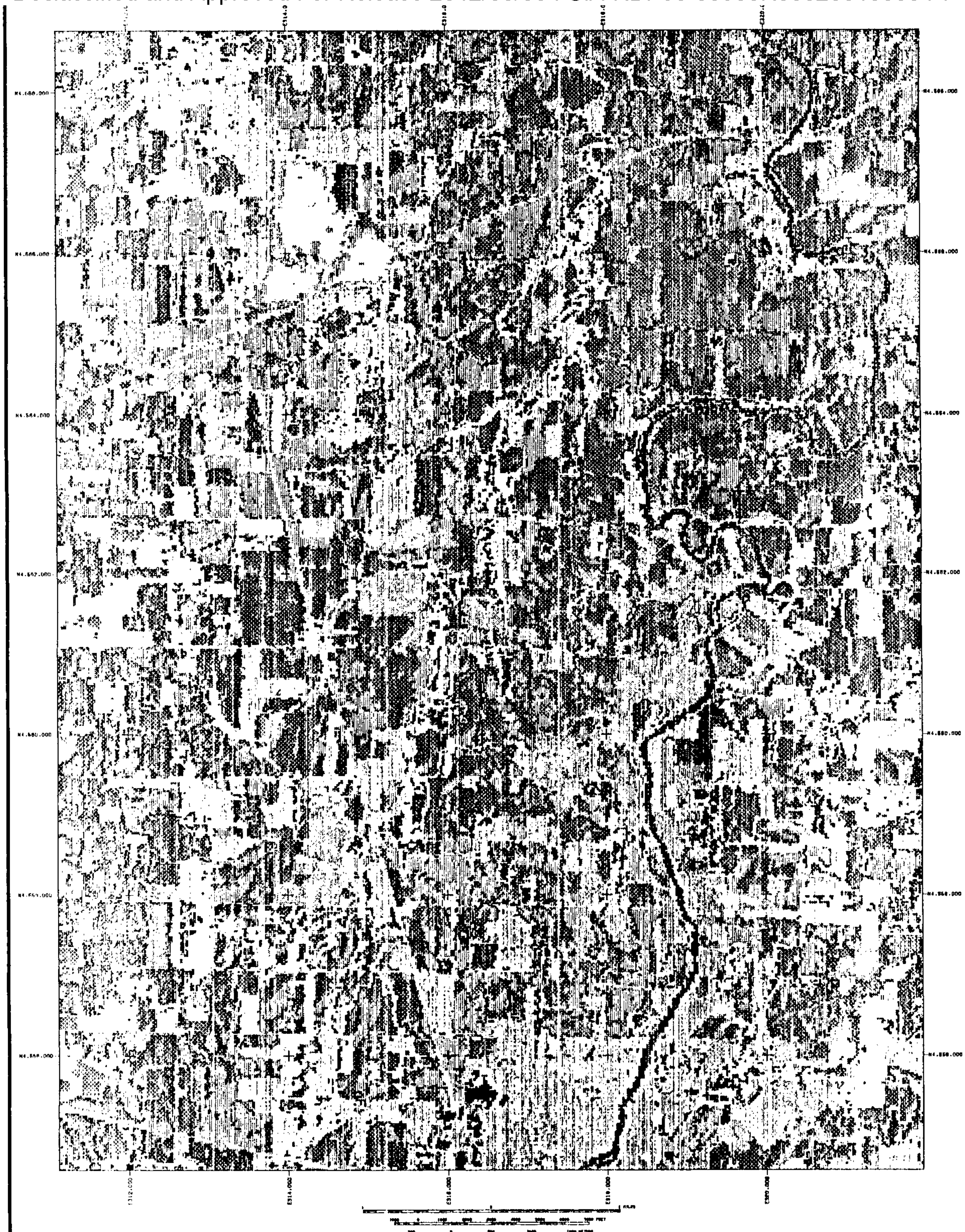

SCALE: 1:24000 2000 METER UTM GRID. ZONE 17

0-15 % RESIDUE	40-75% RESIDUE
0-40 % RESIDUE	> 85 % RESIDUE
15-75% RESIDUE	> 75 % RESIDUE
WOODED	WET SOILS
GREEN VEGETATION	WATER
RAILROAD/URBAN	QUARRY/BRIGHT SURFACES
UNCLASSIFIED	

CLASSIFICATION OF CROP RESIDUE--SENECA COUNTY, OHIO
COMPILED FROM LANDSAT THEMATIC MAPPER DATA ACQUIRED MAY 13, 1985

PREPARED FOR

U.S. ENVIRONMENTAL PROTECTION AGENCY
GREAT LAKES NATIONAL PROGRAM OFFICE

BY

U.S. EPA ENVIRONMENTAL MONITORING SYSTEMS LABORATORY--LAS VEGAS, NEVADA
LOCKHEED ENGINEERING AND MANAGEMENT SERVICES COMPANY
NOVEMBER, 1986

TIFFIN NORTH

APPENDIX A

LEMSCO PERSONNEL RESOURCES FOR INM ENVIRONMENTAL ASSESSMENT STUDIES

RESOURCE/ DISCIPLINE	PERSONNEL	DEGREE	EXPERIENCE
Hydrology	J.C. Rotert	M.S. Hydrology University of Hawaii	**Ten years experience:** groundwater exploration, evaluation and development; extensive on-site investigation for hazardous waste (RCRA and CERCLA), nuclear waste repository; digital simulations and modeling, waste-water, stream flow, run off monitoring; registered professional geologist in California and Arizona.
Environmental Chemistry	R.H. Plumb	Ph.D. Water Chemistry University of Wisconsin	**Sixteen years experience:** interdisciplinary studies to evaluate distribution, behavior, and potential hazards of contaminants in surface water and ground water environments; research and development and evaluation of requirements for dredged materials disposal, ocean disposal; RCRA hazardous waste ground water monitoring programs.
Botany	K.O. Wirtz	M.S. Biological Science University of Nevada, Las Vegas	**Thirteen years experience:** experimental design, collection of samples for taxonomic, anatomical, physiological and trace pollutant analysis; biochemical studies, organic, wet chemistry, water analysis, biotransformations. Plant distribution and relationships. Fluent Spanish.
Soil Science	R.E. Cameron	Ph.D. Plant Science; M.S. Agricultural Chemistry and Soils University of Arizona	**Twenty six years experience:** soils, chemistry, microbiology, microclimatology, and ecological modeling; environmental monitoring, soils quality assurance analysis; developed and implemented training programs in these scientific fields. Member, National Agricultural Research Advisory Board, environmental concerns. International experience in soil sampling, analysis and field coordination. Spanish proficiency.

RESOURCE/ DISCIPLINE	PERSONNEL	DEGREE	EXPERIENCE
Meteorologist	M.J. Pearson	M.S. Atmospheric Physics University of Nevada, Reno	**Twelve years experience:** design and research on environmental field studies. Past studies include visibility impact assessments; remote sensing of air pollution using airborne lidar; multi-media environmental assessments; population dynamics modeling; quality assurance studies related to acid rain; instrument development and evaluation; power plant impact studies.
		REMOTE SENSING SPECIALISTS	
o Physical Geography	F. Mynar, II	M.S. Geography Oklahoma State University	**Seven years experience:** processing and analysis of spectral and spatial remotely sensed data; aerial photo interpretation of hazardous waste sites, establishment of geographic information system (GIS) techniques to model human exposure to environmental pollutants; utilization of aerial photography, aircraft MSS and Landsat MSS and Thematic Mapper in analyses. Specialist in GIS applications utilizing ARC/INFO.
o Economic Geography	S.H. Page	B.A. Geography University of Florida	**Ten years experience:** analysis of aerial photography, aircraft MSS and satellite data for multidiscipline approach to environmental assessments; specialist in historical and intensive analysis of remotely sensed data for surface mining, environmental resource survey, land use - land cover and hazardous waste site, utilized GIS for site analysis techniques.
o Forestry	D.R. Williams	M.S. Forestry Steven F. Austin State University	**Sixteen years experience:** digital and conventional analysis techniques specializing in forestry, vegetation, and wetland studies and inventories; conducted numerous historical wetland and land-use mapping projects in conjunction with EPA monitoring and enforcement investigations.
o Civil Engineering	M.V. Olsen	M.S. Civil and Environmental Engineering University at Wisconsin, Madison	**Eight years experience:** remote sensing and spatial data analysis; digital image processing and GIS applied to environmental monitoring and resource assessment. Considerable experience processing and analyzing aircraft satellite digital data for environmental applications.

APPENDIX B

Literature Search Results

Several comprehensive data base searches were conducted using DIALOG Information Services. Approximately 60 scientific, news, and public affairs data bases were investigated. The search strategies focused on the following topics:

1. Illicit drug crops and cultivation (worldwide).

2. Tropical rainforest deforestation.

3. South American, Central American, Latin American, and Caribbean agriculture (including Jamaica, Columbia, and Peru).

4. Remote sensing technology, scientific research, and tropical rainforests.

5. Marijuana (*Cannabis sativa*), coca (*Erythroxylum coca*) and opium (*Papaver somniferum*).

6. Environmental and ecological impacts and assessments.

A preliminary evaluation of the search results indicate that there is relatively little documented research that specifically addresses the environmental and ecological impact of illicit drug crop agriculture on tropical rainforest deforestation in the geographic areas of interest (Jamaica, Columbia, and Peru). A more thorough review of the literature, as identified by the present searches, should reveal some significant information in the relevant areas subject areas of remote sensing technology, tropical deforestation and agriculture, and the botanical species being examined.

The following list of references represents a portion of the total number of documents and publications identified by the search. References include data base accession number and title only, and have been sorted by data base.

Reference Set 1

REMOTE SENSING AND TROPICAL DEFORESTATION RESEARCH

File 5: BIOSIS PREVIEWS 69-87/JUNE BA8402;RRM3302
(© BIOSIS 1987)

0017505442
BIOSIS Number: 33005442
Deforestation in the Brazilian Amazon Basin Measured by Satellite Imagery

0017505441
BIOSIS Number: 33005441
Tropical Forests, Patterns of Depletion

0017505439
BIOSIS Number: 33005439
AAAS Selected Symposium 101. Tropical Rain Forests and the World Atmosphere

0016602704
BIOSIS Number: 31052782
Remote Detection of Forest Damage

0016520661
BIOSIS Number: 31010869
Spatial Concentration of Deforestation in the Brazilian Amazon

0015008385
BIOSIS Number: 28008385
Using Landsat to Monitor Tropical Forest Ecosystems, Realistic Expectations of Digital Processing Technology

0017107311
BIOSIS Number: 32057112
Continental and Global Scale Remote Sensing of Land Cover

0017023988
BIOSIS Number: 32014121
Local Effects of Tropical Deforestation

0017023987
BIOSIS Number: 32014120
Tropical Deforestation and a Mega-Extinction Spasm

0016082175
BIOSIS Number: 30043007
Tropical Deforestation and Pasture Development

File 6: NTIS - 64-87/ISS15

1245551
N87-18203/6/XAB
Application of Laser-Induced Chlorophyll-a Fluorescence in Forest Decline Research

1043324
DE84004444
Test of the use of LANDSAT Imagery to Detect Changes in the Area of Forest in the Tropics

1023586
DE83016645
Deforestation Measured by LANDSAT: Steps Toward a Method

963787
N83-14579/7
Remote Sensing Techniques for Conservation and Management of Natural Vegetation Ecosystems

909906
N82-20592/3
Amazonas Project: Application of Remote Sensing Techniques for the Integrated Survey of Natural Resources in Amazonas

894125
N82-15490/7
Remote Sensing in Forestry: Application to the Amazon Region

866382
N81-26524/1
Remote Sensing Data Applied to the Evaluation of Soil Erosion Caused by Land Use Ribeirao Anhumas Basin Area: A Case Study

File 8: COMPENDEX - 70-87/JUNE
(© ENGINEERING INFO INC. 1987)

1752502
Global Forests: Another View

1732369
Weather Independent Forest Forest Surveillance by Means of Radar Measurements

1732325
Toward an Economic Model of Deforestation and Social Change in Amazonia

1609920
Identifying Deforestation in Brazil Using Multiresolution Satellite Data

1477424
Reduction of Biological Diversity and Species Loss (Tropical Rain Forests)

1088310
Temporary Hydrologic Changes After Deforestation for Pioneer Homesteading

1037224
Use of LANDSAT Data for Evaluation and Characterization of Deforested Pastureland and Reforested Areas in Brazil

1037192
Land Use Evolution of the City of Rio De Janeiro, Brazil from 1972 to 1978

0994903
Can Forest Policy Contribute to Solving CO_2 Problem?

0976919
Will the World Face Up to Its Ever-Worsening Environmental Problems?

File 10: AGRICOLA - 1979-87/MAY

86068843 85079243 Holding Library: AGL
Improving the Monitoring of Deforestation in the Humid Tropics

86091342 86017894 Holding Library: AGL
Tropical Deforestation and Pasture Development

86091337 86017889 Holding Library: AGL
Saving Tropical Forests; Moving Beyond Documenting the Crisis

86077779 86005661 Holding Library: AGL
Countering the Effects of Tropical Deforestation With Modern Technology

85148031 85019940 Holding Library: AZUA; AGL
Chimera or Opportunity? An Environmental Appraisal of the International Tropical Timber Agreement

85119131 85000360 Holding Library: AZUA: AGL
Possible Climatic Impacts of Land Cover Transformations, With Particular Emphasis on Tropical Deforestation

84114889 84004948 Holding Library: AGL
How Serious is Tropical Deforestation?

81756583 Holding Library: GPO; GPO; AGL
Tropical Deforestation: Hearings Before the Subcommittee on International Organizations of the Committee on Foreign Affairs

82005140 80737693 Holding Library: AGL; AGL
Issues in Tropical Deforestation, U.S. Environmental Protection Agency

81107646 81008605 Holding Library: AGL
Multiple-use Research (Forest Resources)

81074162 80125637 Holding Library: AGL
Tropical Deforestation: Fight for Survival (Forest Management)

874982
Possible Climatic Impact of Tropical Deforestation

File 13: INSPEC - 77-87/ISS14
(© IEE 1987)

1378382
Possible Climatic Impacts of Land Cover Transformations, With Particular Emphasis on Tropical Deforestation

File 41: POLLUTION ABSTRACTS - 70-87/MAR
(© Cambridge Scientific Abstracts)

83-04477
Environmental Priorities: International and Supranational

File 44: AQUATIC SCIENCE ABSTRACTS - 78-87/MAY

1109753 111-09753
Environmental Effects of Deforestation: an annotated bibliography

1603514 116-03514; 216-00768
The Effects of Deforestation in Amazonia

1112969
111-12969; 211-07135
Causes of Environmental Deterioration in Eastern Barbados Since Colonization

1654150 216-04150
On Monitoring Global Change by Satellites

File 50: CAB ABSTRACTS - 1987-87/MAY

0454677
Forest Surveys: Monitoring Tropical Deforestation by Remote Sensing in Latin America

0466089
Cartography of the Environment in Tropical Regions

0369160
Use of Landsat Imagery and Geographical Data Bases for Evaluation of Soil Erosion for Reforestation Planning

0337549
Quantifying Changes in Forest Cover in the Humid Tropics: Overcoming Current Limitations

0229727
Ecology and Development of the Amazon

0145126
Part IV Résource Management. Tropical Rain Forest: Ecology and Management

0220018
Intensive Forest Clearing in Rondonia, Brazil, as Detected by Satellite Remote Sensing

0209089
The Role of Terrestrial Vegetation in the Global Carbon Cycle: Measurement by Remote Sensing

0142264
Remote Sensing Data Applications for the Inventory and Monitoring of Renewable Natural Resources in Costa Rica

0492009
The Effect of Tropical Deforestation on Atmospheric CO_2. Land Clearing and Development in the Tropics

0489507
Hoofprints in the Forest. Cattle Ranching and the Destruction of Latin America's Tropical Rainforests

0361292
Countering the Effects of Tropical Deforestation with Modern Technology. Tissue Culture in Forestry and Agriculture

0241781
Tropical Deforestation and Recovery: The Effects of the Evapotranspiration Process

0227345
The United States Policy on Tropical Deforestation: A Critique

0209231
Technologies to Sustain Tropical Forest Resources

0193439
Tropical Deforestation and North American Migrant Birds

0169982
Replenishing the World's Forests: Tropical Reforestation: An Achievable Goal?

File 53: CAB ABSTRACTS 1972-1983
SEE File 50 (1984+)

1573208 and 1505694
Blowing in the Wind: Deforestation and Long-Range Implications

1305114
Deforestation and CO_2

1145298
Proceedings of the U.S. Strategy Conference on Tropical Deforestation

1030221
How to Save the World. Strategy for World Conservation

File 60: CRIS USDA - 75-87 JUNE

Remote Sensing Techniques to Assess Forest Resources

File 76: LIFE SCIENCES COLLECTION - 87-87/APR

1115159
Deforestation for Sovereignty Over Remote Frontiers in Venezuela

1090719
Explosive Deforestation in Rondonia, Brazil

1026362
Possible Consequences of the Forest Decline in High Mountain Areas

1019467
Identifying Deforestation in Brazil Using Multiresolution Satellite Data

0992213
Desertification: A Threat to World Stability

0975974
Net Flux of Carbon Dioxide from Tropical Forests in 1980

0973782
The Continuing Deforestation of Haiti

0973519
Possible Climatic Impacts of Land Cover Transformations, With Particular Emphasis on Tropical Deforestation

0965694
Effects of Deforestation and Afforestation on Climate

0949192
The Effects of Land Use Alteration on Tropical Carbon Exchange

0854182
Improving the Monitoring of Deforestation in the Humid Tropics

0813562
Succession. (Ecosystem Dynamics; Rain Forests; Tropical Environment; Environmental Impact; Deforestation)

575549
Causes of Environmental Deterioration in Eastern Barbados Since Colonization

0973418
Tropical Forests: A Call for Action. Part I: The Plan

0760610
A Possible Role for Heterotrophs in the Global Carbon Budget

429110
Can the Wet Tropical Forest Survive?

File 68: ENVIRONMENTAL BIBLIOGRAPHY - 74-87/JULY

1509318
Tropical Deforestation and Pasture Development

1508821
International Task Force Plans to Reverse Tropical Deforestation

1306669
How Serious is Tropical Deforestation?

1100360
Raven Warns of Rapid Tropical Deforestation

1001769
Editorial: Tropical Deforestation: Fight for Survival

0906663 and 0906657
Tropical Deforestation: Getting the Green Out

0819100
U.S. Strategy Conference on Tropical Deforestation

File 89: GEOREF - 1785-1987/JULY
(© American Geological Institute)

1. **Deforestation in the Tropics; New Measurements in the Amazon Basin Using Landsat and NOAA Advanced Very High Resolution Radiometer Imagery**

2. **Use of Remote Sensors in the Planning and Evaluation of Exploratory Fields and Their Relation to the Environmental Conservation**

3. **The Carbon Dioxide Question**

4. **Possible Climatic Impact of Tropical Deforestation**

File 103: ENERGY - 83-87/JUN (ISS12)

1317628
DE-87: 003773, EDB-87: 22
Forestry Exemplifying the Transfrontier Pollution Problem

1278904
NOV-87: 044160, EDB-87: 045215
World Resources 1986

1274254
EDB-87: 04565
Continental and Global Scale Remote Sensing of Land Cover Changing Carbon Cycle: A Global Analysis

1111602
EDB-86: 066182
Saving Tropical Forests

1106183
EDB-86: 060763
Countering the Effects of Tropical Deforestation With Modern Technology

372293
EDB-84: 170064
Blowing in the Wind: Deforestation and Long-Range Implications Studies in Third World Societies: Publication No. 14

121635
EDB-83: 121648
Deforestation: Environmental Impacts and Research Needs. Joint Hearing Before the Subcommittee on Natural Resources

024600
EDB-83: 024602
World's Forests

002950
ERA-08: 004618, EDB-83: 002950 TIC Accession No.: DE82019783
Evaluation of Merchantable-total Biomass Conversion Ratios Used in Global Carbon Budget Research

File 104: DOE Energy - 1974-1982 / See File 103

81514
EDB-81: 123410
Earthwatch Global Environmental Assessment

726480
EDB-81: 034734
Deforestation and CO

File 108: AEROSPACE - 62-87/ISS14

149347
Evaluation of Climate Relevant Land Surface Characteristics from Remote Sensing

1487017
Temporal Monitoring of Forest Land Change Detection and Forest Cover Mapping Through Satellite Remote Sensing Techniques

1485347
Forest Inventory in Thailand Using Remote Sensing Techniques

1476751
Support for Global Science: Remote Sensing's Challenge

1438398
Anthropogenic Effects on the Environments According to Observations from Space (Russian Book)

1418651
Scientific Requirements for a Modern-Resolution Imaging Spectrometer

1417774
Application of AIS Technology to Forest Mapping

1413969
Determination of Surface Albedo from Satellites

1367014
Deforestation, Floodplain Dynamics, and Carbon Biogeochemistry in the Amazon Basin

1330391
Multitemporal Change Detection Techniques for the Identification and Monitoring of Forest Disturbances

1301148
Study of Desertification/Aridity Through Remote Sensing

1272028
Test of the Use of LANDSAT Imagery to Detect Changes in the Area of Forest in the Tropics

1272007
Remote Sensing from Space for Forestry Purposes

1201754
Remote Sensing Techniques for Conservation and Management of Natural Vegetation Ecosystems

1183568
Amazonas Project: Application of Remote Sensing Techniques for the Integrated Survey of Natural Resources in Amazonas

1179428
Brazilian Remote Sensing Activities, Current and Prospective Needs

1178478
Remote Sensing in Forestry: Application to the Amazon Region

1171532
What's Happening to the World's Forest Resources (Tropical Regions)

1159482
Monitoring Deforestation in the Eastern Part of the State of Guerrero, Mexico

1159479
Defining the Temporal Window for Monitoring Forest Canopy Defoliation Using Landsat

1159464
A Data Base Approach for Prediction of Deforestation-Induced Mass Wasting Events

1060528
Global Geochemical Problems

0838041
Remote Sensing - Satellite Analyses of Earth Resources

1486983
Evaluation of Digital Change Detection Techniques for Monitoring Tropical Deforestation Using Landsat MSS Data

1418651
Scientific Requirements for a Moderate-Resolution Imaging Spectrometer (MODIS) for EOS

1304262
Using Landsat to Monitor Tropical Forest Ecosystems

File 117: WATER RESOURCES ABSTRACTS - 68-87/JULY

576794
W87-00108
Deforestation Impact Assessment: The Problems Involved

File 165: EI ENGINEERING MEETINGS-87/June
(© Engineering Info INC-87)

0452943
Weather Independent Forest Surveillance by Means of Radar Measurement

0452899
Toward an Economic Model of Deforestation and Social Change in Amazonia

0414315
Analysis of Deforestation in Amazonia Using Shuttle-Imaging Radar

0400551
What the Forest Products Industry is Doing About Pollution-Induced Forest Health Problems

0390050
Uses of Remote Sensing for Monitoring and Control of Deforestation in the High Jungles of Peru

0386733
Some Observations on Remote Sensing of Tropical Environments

0372029
Energy, Hydrogen, and the Environment

0287612
Reduction of Biological Diversity and Species Loss. Tropical Rain Forests

0242710
Tropical Forest Extent and Changes

0215653
Multitemporal Change Detection Techniques for the Identification and Monitoring of Forest Disturbances

0113627
Environmental Deterioration in the Caribbean Island of Hispaniola

0390050
EIM8606-036655
Uses of Remote Sensing for Monitoring and Control of Deforestation in the High Jungles of Peru

0287612
EIM8504-019292
Reduction of Biological Diversity and Species Loss

File 185: ZOOLOGICAL RECORD-78-86 v. 123
(© BIOSIS & ZOOLOGICAL SOCIETY 1987)

0648722
Disappearing Species, Deforestation and Data

File 203: AGRIS INTERNATIONAL 74-87/APR

0936329
Regional Overview of Environmental and Socio-Economic Aspects of Tropical Deforestation in the ESCAP Region

0759800
Possible Climatic Impacts of Land Cover Transformations, With Particular Emphasis on Tropical Deforestation

0408133
The Timber Dilemma Tropical Deforestation in Malaysia

0066085
Possible Climatic Impact of Tropical Deforestation

File 292: GEOBASE 1984 - APR 87

0474507 84V-2059
Univariate Image-Differencing for Forest Change Detection with Landsat

0467811 85L-0339
Remote Sensing Techniques for Conservation and Management of Natural Vegetation Ecosystems

0452946 84V-0479
Effects of Tropical Deforestation on Climate (Forests)

0452944 84V-0480
Tropical Deforestation and Genetic Resources Conservation

APPENDIX C

STATEMENT OF CAPABILITIES AND COMMITMENT

Lockheed Engineering and Management Services Company, Inc. in Las Vegas, Nevada (LEMSCO-LV) is a multidisciplinary environmental sciences organization presently under contract to the United States Environmental Protection Agency (EPA). As a result of our relationship with the EPA, our scientists are researching, developing, and managing monitoring techniques and data analysis programs to assist EPA in solving our nation's most important environmental problems, hazardous waste, ground water protection, and acid deposition.

LEMSCO-LV has a staff of over 230 scientists, engineers, and technical support personnel representing the physical, biological, natural, and earth sciences, as well as chemical, environmental, and geotechnical engineering.

The expertise of LEMSCO-LV's professional staff in the area of hazardous wastes site programs includes preliminary site investigations, design of on-site investigations, environmental monitoring, geophysical surveys, data management, analytical data analysis and interpretation, and quality assurance of analytical data. Utilizing a team approach, LEMSCO-LV personnel interact to develop solutions to complex problems. This integrated team approach will be applied to research on the environmental causes and effects of illicit drug cultivation.

In addition, as part of the Lockheed Corporation, LEMSCO-LV can draw upon the 100,000 member corporate resources for any needed expertise or consultation needed by LEMSCO-LV for this effort. Corporate personnel can be drawn upon for support in technical, scientific, and engineering areas for the various areas of program operations as for previous Lockheed programs including programs not only with EPA, but with NASA, DOE and DOD, and previous work with the U.S. State Department, the Republic of Mexico, and NASA/ERL to develop a means of locating specific vegetative types (narcotics plants) using remote sensing technology.

For the 4-1/2 year Curb Illegal Narcotics Project, Lockheed provided support to NASA/ERL in design, procurement, integration, and installation (in Mexico City) of two powerful minicomputers; design and procurement of a specialized electro-optical airborne sensor; development of remote sensing applications software and associated data processing and analysis techniques; and training of Mexican Nationals (at NSTL and in Mexico City) in computer systems O&M, data processing and analysis, and aircraft data acquisition techniques.

One of the major challenges in this project was providing Lockheed personnel in Mexico City for extended periods of time during hardware installation and checkout, sensor verification, and extensive training of Mexican personnel. This was accomplished by rotating personnel on a one-month basis, which meant considerable persistence in scheduling and coordination to prevent impacts on other ongoing work. Seeing this long and difficult project through to a successful conclusion (both NASA and the Mexican Government considered the project a success) took considerable tenacity.

This is an example of our perseverance and continuing pursuit of excellence in providing service and support to achieve stated goals and objectives.

OPERATIONS

Expertise within LEMSCO-LV lies principally within operational areas of remote sensing, environmental monitoring, environmental chemistry, quality assurance and data analysis. A synopsis of our operational expertise which can be drawn upon for the proposal project is given below.

REMOTE SENSING

The Aerial Photography and Remote Sensing Group is responsible for collecting, processing, and interpreting aerial photography as well as multispectral scanner and laser imagery. LEMSCO-LV uses a Geographic Information System (GIS) supported on a VAX 785 to overlay spatial data such as soils, watersheds, geology, and land use to photographic/scanner data providing an integrated spatial analysis capability. Typical aerial photography/remote sensing projects include spill contingency planning, wetlands mapping, industrial facility investigations, RCRA and CERCLA hazardous waste site investigations, and nonpoint source plume mapping.

ENVIRONMENTAL MONITORING

The Environmental Monitoring Group provides geophysical, air quality monitoring, engineering, and technical support services. The geophysical personnel conduct research to evaluate and improve the application of geophysical monitoring techniques. Geophysical monitoring techniques currently utilized include: electromagnetic induction, resistivity, seismic refraction, magnetics, and high precision gravimetry. LEMSCO-LV scientific and engineering personnel have developed a passive soil gas sampling system for detecting contamination from leaking underground storage tanks and in groundwater. We have designed, developed, and managed a number of large scale air monitoring and meteorological networks. Several projects required the design, fabrication, and installation of monitoring systems in remote locations necessitating the use of solar power and satellite telemetry.

We have an excellent track record in designing, implementing, and managing environmental field studies. Drawing upon resources throughout the organization, LEMSCO-LV project managers utilize an integrated systems approach to coordinate the movement of people, equipment, and samples to and from the study site. Such a system was used in the successful completion of the National Surface Water Survey for which LEMSCO-LV personnel have received some of the highest awards ever given a contractor by the EPA. Past EPA Administrator William Ruckleshaus cited the LEMSCO-LV project management efforts as a model for future EPA field programs.

Representative LEMSCO-LV projects include the National Lake Survey Phases I and II, National Stream Survey, National Soil Survey, Spring Variability Survey, and the National Snow Survey Pilot Program.

ENVIRONMENTAL CHEMISTRY

The Environmental Chemistry Group specializes in analytical chemistry and associated sampling, sample handling, analytical methods development, occupational safety, and groundwater and surface water monitoring. Over 50 analytical chemists are on staff to develop and evaluate new analytical methods and to prepare standard reference materials for the EPA's RCRA, CERCLA, Acid Deposition, Toxics, and Pesticides. These chemists routinely perform environmental programs in chemical analysis of environmental samples and operate and maintain a wide variety of analytical instrumentation which enables the LEMSCO-LV chemistry personnel to investigate virtually any chemical of interest in modern environmental science. Recent programs in the development phase include the application of biotechnology to chemical analysis, the use of fiber optics to perform *in situ* chemical analysis, and the application of modern synthetic organic chemistry to problems in environmental organic chemistry and analysis.

Additionally, LEMSCO-LV chemistry personnel are involved in the evaluation of the present RCRA water regulatory strategy. These personnel also perform extensive literature reviews to compile Quality Assurance, Quality Control, and Performance Data for routinely used measurement methods to aid Project Managers in the selection of analytical techniques.

QUALITY ASSURANCE AND DATA ANALYSIS

LEMSCO-LV personnel are national experts in evaluating chemistry data. LEMSCO-LV Quality Assurance personnel are directly responsible for developing and managing the existing quality assurance programs for data collection, chemical analysis, and interpretation for the Superfund Contractor Laboratory Program, RCRA, and the National Surface Water Survey. By utilizing sophisticated statistical techniques, and computerized data management systems, LEMSCO-LV personnel audit the results of laboratory chemical analysis to assure that each data value is of known and prescribed quality, accuracy, and precision.

Representative projects include evaluation of the hazardous waste sampling and analysis program for the Department of Defense and Department of Energy, assisting the EPA Groundwater Monitoring Task Force in evaluating data from hazardous waste disposal sites, and providing the necessary multi-laboratory method validation of Superfund analytical methods.

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