United States
Environmental Protection
Agency

Environmental Monitoring
Systems Laboratory
Las Vegas, NV 89193-3478

Research and Development

EPA/620/SR-94/015 July 1994

EPA

Project Summary

Environmental Monitoring and Assessment Program—Arid Ecosystems 1992 Pilot Report

Susan E. Franson

The U.S. Environmental Protection Agency (USEPA) and its collaborators have initiated a long-term, policy-relevant research project, the Environmental Monitoring and Assessment Program (EMAP), focused on evaluating ecological conditions on regional and national scales. In 1992 the EMAP Arid Ecosystems Resource Group (one of a number of EMAP resource groups) conducted a pilot study in the southeastern Utah portion of the Colorado Plateau. This report describes this first field activity for arid ecosystems. The 1992 pilot study was developed to evaluate sampling plot design and the sensitivity of selected indicators. The study focused on four objectives related to plot design, indicator development, sampling frame material, quality assurance, information management, and logistics. The primary categories of indicators selected for evaluation in the 1992 pilot study were vegetation composition, structure, and abundance; spectral reflectance; soil properties; and soil erosion. Data were collected on 29 sites within two major resource classes—desertscrub and conifer woodland. Indicator measurement methods and the study results for each of the four objectives are explained in this report. Each of these sections includes recommendations based on the 1992 study. The final section summarizes the major conclusions and recommendations drawn from the 1992 pilot study, draws implications from the study results, and discusses planned future studies.

Introduction

In 1992 the Arid Ecosystems Resource Group conducted a pilot study in the southeastern Utah portion of the Colorado Plateau. The purpose of this EMAP group is to measure and report on the extent, condition, and trends of several resource classes in the biogeographical provinces of nearctic and neotropical North America within the United States.

The study focused on four objectives:

- Assessment of sampling variance—Evaluation of the EMAP-Forests Resource Group sampling plot design relative to the selected indicators.
- Indicator sensitivity—Evaluation of the sensitivity of the indicator measures to independent evaluations of site condition as designated by various land management.
- Sampling frame and extent—Evaluation of the utility of using classified TM imagery and other data acquired from the U.S. Fish and Wildlife Service (FWS) Gap Analysis Program (GAP) to select frame materials for the pilot study and future studies and to provide data for extent estimation of arid ecosystems.
- Quality assurance, information management, and logistics—Evaluation of the quality assurance, information management, data analysis, logisti-

cal, and reporting requirements and constraints based on the pilot study area.

1992 Pilot Study Area

The Colorado Plateau is an arid and semi-arid tableland in the southwestern U.S. The entire 130,000-square mile region of the Colorado Plateau is much more extensive than needed to fulfill the requirements of the intended indicator evaluation pilot; therefore, only a portion of the plateau was chosen for data collection. This region is predominantly managed as federal lands, (i.e., Bureau of Land Management, National Park Service, and Forest Service, and part of Navajo Nation, state, and private lands). The diversity of ownership and jurisdiction promoted interagency participation in the pilot implementation. The area is bisected by the Colorado River and includes many canyon lands that allowed for evaluation of logistical requirements in some of the most difficult terrain that EMAP-Arid activities will likely face. The area includes two resource classes which are prevalent within the Colorado Plateau (desertscrub and conifer woodlands) that were chosen for indicator evaluation.

Indicator Measurement Methods

Vegetation Composition, Structure, and Abundance

Vegetation composition and structure have been evaluated for decades in arid ecosystems and are well established as important indicators of ecosystem condition. The difficult decision for the 1992 pilot was to determine what type of measurement technique best fit within the EMAP approach. Numerous vegetative sampling techniques were evaluated including plot sampling, belt transects, and line intercept techniques. Most of the vegetative sampling techniques have been developed for measuring forage supplies for big game and other herbivores. The literature was reviewed and the EMAP-Arid researchers decided to use a modified Daubenmire (1968) approach because it provides the ability not only to measure vegetation attributes about species richness and diversity, but also to keep open options for relating this information to wildlife habitat in future pilots.

Spectral Reflectance

A remote sensing approach to collect information about a site offers a number of advantages for indicator development such as producing spatially explicit estimates of ecological condition over entire regions in a cost-effective manner. A number of researchers have developed strong relationships between measurements and indices derived from remote sensing and ecosystem variables. The Normalized Difference Vegetation Index (NDVI) is such an index and researchers have shown very high relationships between NDVI developed from satellite and ground measurements and leaf area index. The leaf area index correlates strongly with a number of other extremely important ecosystem variables such as primary productivity and biomass. The NDVI was selected as a candidate indicator for the 1992 pilot study because it has both a demonstrated relationship to vegetation parameters and a lack of sensitivity to atmospheric conditions; in addition, it has been used to monitor phenological (vegetation) variables on regional, continental, and global scales. The Landsat TM satellite data were used to determine NDVI because the waveband location for deriving information concerning vegetation parameters is superior to multispectral scanner (MSS) data and the pixel size of 30 by 30 m correlates more easily with field-based measurements than does the 1.1- by 1.1-km pixels of the Advanced Very High Resolution Radiometer.

Soil Properties and Soil Erosion

Soil properties were selected because they were determined to be critical in evaluating ecosystem health and interpreting vegetative information. The literature provided the rationale for looking at (physical, chemical, and biological crusts) soil parameters and focusing on their implications to management options, plant growth and the water balance. Soil erosion was also included in the 1992 pilot because most of the data required for estimating erosion were collected in the soil profile. These data could then be used as inputs to the Revised Universal Soil Loss Equation (RUSLE) erosion models for evaluating the relationship between soil erosion and site condition. Several researchers have identified a positive correlation between increased runoff and erosion with a decrease in the seral stage of arid ecosystems and have evaluated the sensitivity of the models.

Assessment of Sampling Variance

The process of collecting samples can produce extraneous variability in the indicator measurements in addition to the variability associated with the resource condition. The EMAP survey design protocols include annual visits to sampling sites throughout the region and will require multiple sampling crews to procure the measurements within adequate time frames. The utility of indicators of resource condition to some extent depends upon the degree to which these extraneous sources of variation inhibit the ability of the indicator measurement to describe resource characteristics. Knowledge of these variance values is necessary not only to construct confidence intervals for the measured indicators but also to evaluate the viability of the measurements as indicators. The magnitude and influence of each of these components of variability must be evaluated by the EMAP-Arid program as it progresses through the indicator development process. Variance components that continue to require a high level of investigation include those associated with the year, crew, measurement, and plot design.

The evaluation of indicator measurement variances associated with the sampling units that potentially could be used in a common plot design for monitoring EMAP-Arid extensive resources was a primary objective of the 1992 pilot study. Year and crew components of variance were not considered for investigation in the 1992 pilot study and will be determined from larger and long-term studies in the future. Measurement variances are discussed in Section 7 of the report.

Measurements considered most influential for the spectral, vegetation, and soils indicator categories were selected as candidates for evaluation of their variance properties. The variable selected for the spectral measure was the NDVI; the variables selected for vegetation measurements were total vascular plant cover, shrub cover, and tree cover; and the soil variables analyzed were the clay, silt, sand, and very fine sand percentages; organic matter; the soil erodibility factor (K); and the length-slope (LS) steepness factor.

The variables for this analysis also were selected to represent measurements acquired from different components of the plot design. The selected variables are each representative of uniquely different types of statistical variables which affect how the indicator variables are used in the analyses. Each category of indicator measurements is discussed separately.

It is recommended that a study be conducted to determine an optimal integrated response design for EMAP-Arid monitoring. Such a study should be conducted using a uniform sampling grid that allows a wide range of arrangements of the basic measurement units from linear transects of varying lengths to varying shapes and sizes of rectangular arrays of the units. The relationships of the arrange-

ments to their respective variances can be used to craft efficient sampling designs at a site. Also, this type of study would result in data to estimate the level of spatial correlation that can be expected from the measurements. Knowledge of the spatial correlation would indicate the need for any spatial separation among the measurement units to increase the amount of independent information acquired from the units.

Indicator Sensitivity

One of the primary aims of the indicator evaluation process is to evaluate the degree to which individual indicators represent a range of ecological condition. This is often referred to as evaluation of indicator sensitivity. Two general types of indicator sensitivity are commonly evaluated: the grouping or clustering of indicator values across an environmental gradient and the degree to which an indicator varies within a known range of conditions.

The first type of sensitivity analysis normally involves recognition of patterns or clusters (pattern recognition or detection) of values of indicators across an environmental gradient. The study is designed to determine if indicator values will separate or cluster into one or more groups and whether the groups correspond to the environmental gradient. This design allows an evaluation of indicator sensitivity to a range of environmental conditions, even if standards (desired conditions) for evaluating condition are not known.

The second type of sensitivity analysis generally involves selecting sample sites based on a range of "known" or "desired" conditions and evaluating the degree to which indicators vary across those conditions. This type of sensitivity analysis requires an *a priori* agreement on what constitutes condition (nominal, marginal, subnominal) and knowledge of the geographic range of the condition (so that representative sites can be selected).

Initially, the EMAP-Arid researchers had intended to evaluate indicator sensitivity relative to known or desired conditions as determined by existing information available from federal land management agencies. The EMAP-Arid team decided to conduct this initial pilot study in the Colorado Plateau due to the wealth of information available from this area. Discussions were held with a number of management agencies and these discussions led to the understanding that EMAP-Arid could obtain congruous determinations of site condition for the Colorado Plateau area. However, the EMAP team discovered significant differences in agency descriptions of the condition of a site. This difference was substantial enough in several cases that no consistent rating of a site could be established. Recently, similar concerns have also been reported by the NRC in their review of rangeland health. As a result of these factors, the 1992 pilot study was not able to address the objective to evaluate indicator sensitivity against sites of "known" condition. Results presented in this report are only indicative of patterns in the Colorado Plateau and the actual range condition, delineated in these patterns, is not known. However, it is reasonable to assume the sites were different and represented at least a partial range in condition.

Frame Materials

The EMAP-Arid group definitions of vegetation resource classes, as well as biogeographic provinces have been established. A method, or set of methods, to estimate extent of arid resources needs to be developed, with the idea that an area sampling technique will provide a better estimate of extent.

An evaluation of the FWS GAP information was conducted to determine how well the satellite-derived data base identified plant communities found at the pilot study sample points. It is important to note that the GAP data used were considered "preliminary", and have been improved since the initial comparison was made.

The evaluation of the GAP data was inconclusive partly because, for a comprehensive evaluation, more sites are needed, and, some discrepancies appeared to exist. If the EMAP-Arid group wants to consider using GAP data in the future to select frame materials and to provide data for extent estimation of arid ecosystems, then a further assessment of the accuracy of the GAP data must be performed. This assessment should be done on the second generation (or the most recent version) of the GAP data and must include a sufficient sample number for each land cover type.

Quality Assurance, Information Management, and Logistics

Quality assurance (QA), information management, and logistics are integral components of EMAP field activities. In a program of the magnitude of EMAP, overlooking or ignoring even apparently minor issues or details may eventually jeopardize the success of the program. Planning and documenting QA, information management, and logistics activities are essential. The report documents these activities for the 1992 pilot study.

Conclusions and Recommendations

The 1992 pilot study was the first EMAP-Arid field study, and addressing the objectives developed for this study is essential to full implementation of the program. Questions related to these objectives will continue to be important elements in planning for future pilot studies. During the 1992 pilot study, the EMAP-Arid team was successful in partially addressing these objectives but, more importantly, the planning and implementation of this study uncovered issues that were not fully understood or perceived in initial design efforts. For example, the original assumptions that the EMAP-Forest design would be applicable to EMAP-Arid indicator measurements or that independent site condition assessments from land management agencies could readily be used to evaluate sensitivity of indicators were inaccurate. Only as the 1992 field work progressed were these difficulties pinpointed.

The USEPA, through its Office of Research and Development (ORD), funded and collaborated in the research described here. It has been peer-reviewed by the Agency and approved as an EPA publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Susan E. Franson (also the EPA Project Officer, see below) is with the Environmental Monitoring Systems Laboratory, Las Vegas, NV. 89193-3478.

The complete report, entitled "Environmental Monitoring and Assessment Program—Arid Ecosystems 1992 Pilot Report," (Order No. PB94-176898/AS; Cost: $27.00; subject to change) will be available only from:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650

The EPA Project Officer can be contacted at:

Environmental Monitoring Systems Laboratory
U.S. Environmental Protection Agency
Las Vegas, NV 89193-3478

United States
Environmental Protection Agency
Center for Environmental Research Information
Cincinnati, OH 45268

Official Business
Penalty for Private Use $300

EPA/620/SR-94/015

BULK RATE
POSTAGE & FEES PAID
EPA
PERMIT No. G-35