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Project Summary

Environmental Monitoring and Assessment Program: Arid Ecosystems 1993 Implementation Plan—Colorado Plateau Plot Design Pilot Study

William G. Kepner

This implementation plan describes the basis for activities planned during 1993 in the southeastern Utah portion of the Colorado Plateau. Ecological interpretation of information gathered on monitoring sites requires plot configurations that provide sufficient areal support to capture the characteristics of the biological communities. The study objective and approach of the 1993 pilot study are to determine the sampling support area and optimum plot size for selected indicator measurements (spectral properties, vegetation composition and abundance, and soil properties). Plot size variance and configuration relationships along with cost of data collection in terms of available resources, e.g., time and money, will be used for optimal plot design evaluations.

This Project Summary was developed by EPA's Environmental Monitoring Systems Laboratory, Las Vegas, NV, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The U.S. Environmental Protection Agency (EPA), in collaboration with other federal agencies, states, research institutes, and university systems, has initiated the Environmental Monitoring and Assessment Program (EMAP) to develop a long-term approach to assess and periodically document the condition of ecological resources at the regional and national scales and to develop innovative methods for anticipating emerging problems before they reach crisis proportions. The goals of EMAP are to monitor and assess the condition of U.S. ecological resources and to contribute to decisions on environmental protection and management.

To accomplish its goals and objectives, EMAP has established eight ecosystem monitoring and research groups (i.e., estuaries, coastal waters, Great Lakes, surface waters, forests, agroecosystems, arid ecosystems, and landscape ecology) and seven cross-system program groups (i.e., design and statistics, quality assurance, information management, landscape characterization, indicators, methods and logistics, and assessment and reporting). This implementation plan describes the basis for activities planned during 1993 by the EMAP arid ecosystems monitoring and research group.

Arid ecosystems, as defined by EMAP, are terrestrial systems characterized by a climatic regime where potential evapotranspiration exceeds precipitation, annual precipitation ranges from <5 to 60 cm, and daily and seasonal temperatures range from -40 to 50°C. The vegetation in arid ecosystems is dominated by woody perennials, graminoids, succulents, and drought-resistant trees. Physiognomy is generally low-form and canopies typically open. Arid ecosystems include associated riparian communities; however, intensively managed agriculture, such as irrigated farmlands, is excluded even though it may occur in the same climatic region.

The EMAP Arid Ecosystems include arid, semiarid, and subhumid regions of the United States and occupy much of the land surface area (excluding high-elevation forests) west of 95° W longitude. EMAP-Arid is one of three EMAP Terrestrial Resource Groups that are progressively interacting in activities as the program matures.

The objectives of the EMAP Arid Ecosystems resource monitoring and research group (EMAP-Arid) parallel those established for EMAP. It is the intent and purpose of EMAP-Arid to measure and report on the extent, condition and trends of resource classes (i.e., arid subpopulations) within the biogeographical provinces of nearctic and neotropical North America that occur within arid, semiarid, and subhumid climatic regimes. A number of pilot and demonstration projects will be required in the next few years to develop indicators of the condition of arid ecosystems and measurement procedures prior to achieving full implementation.

Environmental indicators are being developed to collectively describe the condition of an arid ecosystem. Indicators "common" to the EMAP Terrestrial Resource Groups will be fostered by the EMAP-Arid group. The operating strategy is model based and identifies regional issues and assessment questions, links them with societal values that have biological relevance, and identifies indicators that, when measured and integrated, can evaluate the status and trends in the condition of arid ecosystems. Issues that have been identified as regionally important in arid ecosystems are desertification, livestock grazing, biodiversity, water resource management, air quality, and global climatic change. Three societal values are currently identified as significant to arid ecosystems and have served to focus the conceptual development of the monitoring and research strategy for EMAP-Arid, especially relative to the selection and use of indicators. These values are

- Biological integrity—species composition and structure (abundance and spatial arrangement) of biotic and abiotic elements and their associated functions (ecological processes at various levels (i.e., genetic, species, population, community, ecosystem, and landscape) of biological organization.
- Aesthetics—broadly defined as attributes that affect human perception and appreciation of the environment.
- Productivity—the quantity and quality of ecological and nonconsumptive services or products provided by arid resources and their capacity for long-term maintenance.

The EMAP-Arid group has elected to develop its first research indicators relative to productivity and biological integrity, significant social concerns relating to the critical issues of desertification and climate change in western North American landscapes. Various measures, attributes, and indices are being evaluated as indicators related to specific indicator categories. Three indicator categories of arid ecosystem condition (spectral properties, vegetation composition and abundance, and soil properties) were tested during the summer of 1992 in the southeastern Utah portion of the Colorado Plateau. The 1993 activities will concentrate on the development of optimal field plot sampling designs from which to obtain measurements for the three indicator categories evaluated in the 1992 Pilot Study.

Study Objective and Approach

The study objective and approach of the 1993 EMAP-Arid pilot study is to determine the sampling support area and optimum plot size for selected indicator measurements. Interpretation of ecological condition at EMAP-Arid monitoring sites requires an adequate representation of the vegetation and soils communities at a site. A number of criteria have been used by researchers to determine the minimum plot size and shape required to adequately describe an area. The measurement of variables for indicators on EMAP-Arid monitoring sites is intended to reflect the status of plant and soil communities present in the sampled resource community. Thus, it is important that the sampling support area is of a sufficient size to adequately characterize those indicator variables for the plant and soil communities under consideration. The approach to determining the EMAP-Arid indicator sampling support area and plot design will be based to some extent on the research conducted by others. However, the EMAP-Arid survey requirements for sampling plots will differ from other studies in several facets. The sampling plots will have to serve as monitoring sites for a multiplicity of measurements with the potential for repeated visits to the site over decades. Complete census of the plots may be neither feasible nor desirable under these circumstances. They must be set up with minimal disturbance to the measurement areas. The number of plots or replicate samples at the site for monitoring purposes will be the number required for specified confidence estimates in the survey. Thus, questions of replication blocking with different treatments on the plots within blocks as in experimental trials are not relevant to the survey.

The field sampling areas required for this study will be coordinated and integrated by the three indicator groups. Large macroplots estimated to be larger than the indicator sampling support area will be established at each site and intensively sampled. Each macroplot will be selected so that it is in a single landscape unit. These macroplots will be established in three biomes (in parallel EMAP terms, these are research types)—desertscrub, woodland, and grassland. The macroplots will be the basis for a uniformity sampling trial at each site. Plots of varying configurations can be crafted from the uniformity sampling trial on the macroplot to evaluate their qualitative and quantitative properties. Each macroplot is subdivided into a rectangular array of basic sampling units. The area within a basic unit required for a particular measurement will vary with the type of indicator category measurement. The measurement areas may be small quadrats for vegetation cover measures, a soil sample, or spectral reading area. The measurement taken in these areas will be sufficient to represent the characteristics of the basic unit. The arrangement of measurement areas, relative to one another within the basic units, will be set up to accommodate sampling logistics that are anticipated at a monitoring site for future surveys.

The goal is to have a cost-efficient sampling strategy that is sufficient to provide an adequate description of the vegetation and soils community at the site. The relationship between properties of indicator parameters and the plot size and shape will be established and estimated for all measurements most critical to the quantifiable indicators identified for EMAP-Arid monitoring. A final plot design operationally feasible for indicator measurement purposes in a future EMAP-Arid demonstration survey will be determined from data collected in 1993 on these large macroplots.

Study sites for 1993 were selected to represent readily observable differences in biome and productivity combinations; however, every possible combination is not represented because of time and cost constraints. The desert scrub biome is the most extensive biome in the Great Basin biogeographic region. Low-, medium-, and (medium) high-producing sites were selected to represent this major biome. A medium producing grassland and high-producing pinyon-juniper site were also selected. Low-producing grassland and pinyon-juniper sites are rare in the Great Basin biogeographic province.

Macroplot Design

Ecological interpretation of information gathered on monitoring sites requires plot configurations that provide sufficient areal support to capture the characteristics of the biological communities. The general 1993 macroplot design to determine the sample support area and optimum plot design is shown in Figure 1. Plot size variance and configuration relationships along with cost of data collection in terms of available resources, e.g., time and money, will be used for optimal plot design evaluations. Optimal plot design will be determined empirically for all important indicator measurements via uniformity sampling trials with nested plot designs on three EMAP-Arid formation types or biomes, i.e., desert scrub, grassland, and conifer woodland (pinyon-juniper). This study needs to precede or coincide with indicator development before undertaking projects at the survey demonstration level. Macroplot sampling areas are designed for vegetation, harvester ants, spectral properties, and soils.

Indicators

The EMAP indicators are being developed as characteristics of the environment that, when measured, quantify the magnitude of stress, habitat characteristics, degree of exposure to stressors, or the degree of ecological response to an exposure. Indicators serve as the basis for quantification of the assessment endpoints (i.e., the actual measurements to be made). In the 1993 EMAP-Arid Colorado Plateau Plot Design Pilot Study, the same three indicator categories and measurements used in the 1992 pilot will be studied to determine the optimum plot size for each. The three indicator categories are vegetation composition and abundance, spectral properties, and soil properties.

The composition, structure, and abundance of vegetation have been recognized

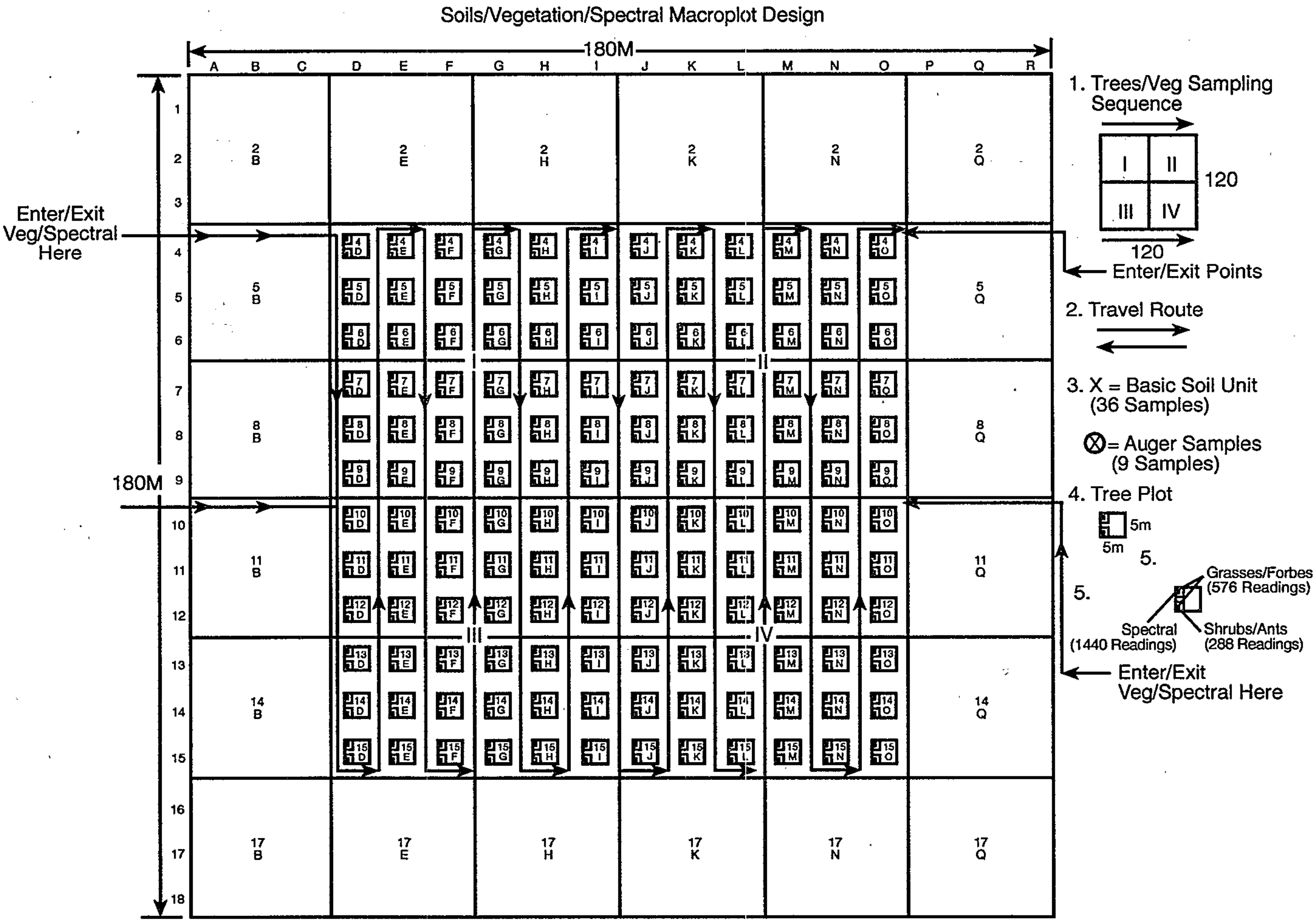

Figure 1. *Macroplot design for soils, vegetation, and spectral properties indicators.*

as useful indicators of environmentally induced changes in arid vegetation. The proposed measurements for the determination of these indicators are estimation of (1) the percent cover and (2) the height of the green vegetation on the site by species. Together these measurements can provide an index of leaf area and serve as sensitive indicators of change in biological condition at the organism, population, community, and ecosystem levels.

Electromagnetic radiation provides information about the physical and chemical properties of materials. While the spectral reflectance properties of objects tend to be wavelength dependent, the determination of these relationships is critical for characterizing or discriminating the objects. Vegetation, soils, and other materials have spectral responses that are a function of a diverse array of properties of those materials. These properties might include moisture content, shadowing, and presence of other materials. Nevertheless, the overall spectral response of a material is largely a function of the material itself. Spectral measurements will be made to determine if vegetation condition and soil properties can be related to spectral signatures collected by satellite, hand-held spectrometers, or both. Ground spectra will be collected using a portable field spectrometer. The 1993 Plot Design Pilot Study will focus on correlating the spectral reflectance measured on the ground with that determined from various satellite platforms to estimate vegetation and soils features.

Selected soil properties will be measured in the field and lab as indicators of soil erosion, productivity, and moisture-plant growth indices. Local soil characteristics and soil surface and subsurface samples will be obtained using established methods from the U.S. Soil Conservation Service. Local soil characteristics will be used to evaluate type of soil and to calculate an erosion index. Surface physical and chemical soil attributes are obtained from samples collected at the surface. Surface soil properties are one of the first attributes to respond to natural and anthropogenic stress. Deep soil profile observations will be collected to classify the soil. Most of the measured soil properties provide baseline data that would only be resampled if notable changes occurred in other indicators. The data can then be used for comparison extrapolation and interpolation of long-term change.

The following research questions will be assessed in addressing the 1993 EMAP-Arid objective:

1. What is the relationship between indicator measurement properties and the size and shape of plot for selected vegetation, soils, and spectral indicator measures?
2. What are the costs associated with setting up and sampling basic units for measuring the selected vegetation, soils, and spectral indicator categories?
3. What are the sizes and shapes of plots that maximize the amount of information per unit cost for the selected vegetation, soils, and spectral indicator measures?
4. What are the effects of spatial correlation patterns, if they exist, on the choice of plot size and shape?
5. How similar are the variances and correlation patterns across EMAP-Arid subpopulation formation types?

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*The EPA author, **William G. Kepner,** is with the Environmental Monitoring Systems Laboratory, Las Vegas, NV 89193-3478.*

***Daniel T. Heggem** is the EPA Project Officer (see below).*

The complete report, entitled "Environmental Monitoring and Assessment Program: Arid Ecosystems 1993 Implementation Plan—Colorado Plateau Plot Design Pilot Study," (Order No. PB94-165339; Cost: $19.50; 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

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Cincinnati, OH 45268

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