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Environmental Monitoring
Systems Laboratory
Las Vegas, NV 89193-3478

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# Project Summary

# Environmental Monitoring and Assessment Program: EMAP-Arid Colorado Plateau Pilot Study - 1992: Implementation Plan

Susan E. Franson

**The 1992 Colorado Plateau Indicator Pilot Study, the first field activity for the EMAP-Arid group, is designed to evaluate several indicators of arid ecosystem condition for continued development and implementation for monitoring. This Implementation Plan describes the conceptual approach for the pilot study; questions that will be addressed in the study; the rationale and process that led to the choice of a portion of the Colorado Plateau for the study site; and the rationale and process for selection of the indicators to be tested. The overall EMAP-Arid design is presented along with the specifics for the pilot study and the sampling plot designs. Logistics, quality assurance, information management and geographic information system (GIS), and analysis and reporting of the pilot study results also are addressed.**

**The bulk of the implementation plan describes the indicator categories that are to be evaluated in the pilot study: vegetation composition, structure, and abundance; soil properties including erosion potential; and spectral properties of vegetation and soils from both on-ground and remote sensors. These indicator categories were chosen for their potential to relate to the issues of sustainability and desertification which are of critical importance to arid ecosystems. An appendix describes retrospective and landscape indicators that will be further developed by EMAP-Arid in the future.**

***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

In response to the growing awareness of regional and global-scale environmental degradation brought about by the combined actions of all peoples on Earth, nations throughout the world are acknowledging the need to obtain critical scientific information and are establishing environmental monitoring networks to assess the condition of their important ecological resources. The U.S. Environmental Protection Agency (EPA), in collaboration with other federal agencies, 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 regional and national scales and to create innovative methods for anticipating emerging problems before they reach crisis proportions. Desertification, livestock grazing, biodiversity, water quality and quantity, air quality, and global climatic change have all been identified as regionally important issues in arid ecosystems. EMAP-Arid will monitor and report on the condition of arid and semi-arid ecosystems.

Arid and semi-arid ecosystems occupy nearly all of the land surface area (excluding high-elevation forests) west of 95° West longitude in the conterminous United States. Much of this land is publicly owned and managed by various state and fed-

eral agencies. Because of the widespread interest in arid ecosystems, and to take greatest advantage of all available expertise, the EMAP-Arid team is composed of scientists from various universities, research institutes, public interest groups, and federal agencies. The success of the pilot study is dependent upon this mixture of affiliations that includes EPA, the Bureau of Land Management (BLM), National Park Service (NPS), Forest Service (FS), Soil Conservation Service (SCS), Fish and Wildlife Service (FWS), and the Navajo and Ute Nations.

The Implementation Plan provides the mechanism for coordination of indicator development and evaluation with members from participating agencies and the external scientific community. The Implementation Plan gives an overview of the pilot study from a technical perspective. A companion document, the Field Operations and Training Manual, presents the operational aspects of the study, including (1) detailed protocols for each step of the field work; (2) a Safety Plan; and (3) a Quality Assurance Project Plan.

## Conceptual Approach

EMAP-Arid is following a strategic plan based in part on the National Research Council (NRC) and EMAP guidelines for designing and implementing environmental monitoring programs (Figure 1). The Colorado Plateau Pilot Study - 1992 represents the step in which exploratory studies are conducted. The pilot study is one type of exploratory study, generally intended to answer specific questions about indicator performance, including sensitivity, components of variance, data collection protocols, and logistical requirements. Pilot studies are not intended to provide estimates of ecological condition.

The Colorado Plateau Pilot Study will evaluate and field test a number of issues related to design, ecological indicators, quality assurance, logistics, information management, and analysis and reporting before full scale implementation. Results will be used to plan future pilot studies and to develop regional demonstration projects leading to full scale implementation.

The specific objectives of the pilot study are:

1) To gather and evaluate information to move selected ecological indicators from the "research" category to the "development" stage in the indicator implementation process.
2) Evaluate the utility of using classified Thematic Mapper imagery and other data acquired from the FWS GAP Program to select frame materials for the pilot study and to provide data for extent estimation of arid ecosystems.
3) Evaluate the sampling plot designs appropriate to the selected indicators.
4) Evaluate the logistical, quality assurance, information management, data analysis, and reporting requirements and constraints based on the pilot study data.

For each of these objectives, specific questions have been formulated that the pilot is designed to answer.

## Site Selection and Description of the Study Area

In selecting an area for the pilot study, regions were first considered based on the availability of ecological data relevant to addressing questions of sustainability and desertification. A decision analysis process developed by Kepner and Tregoe (K-T Analysis) was used to select the pilot study area from the list of candidates. Criteria that the study site should meet so that the study objectives could be achieved were defined. These criteria included the relationship of the study area to the issues of desertification and global climate change; the availability, quality, and quantity of data relevant to sustainability, retrospective data, and remote sensing imagery; and the opportunity for collaboration with other EMAP groups. Each site was scored based on how well it met each of the criteria. This process resulted in the selection of the Colorado Plateau for the location of the study area.

Figure 2 shows the Colorado Plateau region with the 1992 pilot study area in Southeastern Utah shaded. The Colorado Plateau is an arid and semi-arid tableland in the southwestern United States. The Plateau supports a great diversity of ecosystems including cold deserts; alpine tundra; hanging gardens; woodlands; shrublands; and cryptogamic communities of mosses, lichens, fungi, and cyanobacteria comprising most of the biomass on otherwise sterile soils.

## Design

The EMAP design specifies a probablistic sample based on a random systematic triangular grid with 27.1 km between nearest neighbor grid points. The EMAP-Arid design conforms to the overall EMAP design. The design of the pilot specifies sampling at points offset from the EMAP grid points. This offset allows testing of the EMAP design in arid systems while avoiding any possible interference with the site that will be sampled in implementation.

The population of interest to EMAP-Arid is composed of those terrestrial systems where potential evapotranspiration exceeds precipitation; annual precipitation ranges from < 5 to 60 cm; air temperatures range from -40 to 50°C; and vegetation is dominated by woody perennials, graminoides, succulents, and drought-resistant trees in low-form, open canopies. Arid lands include associated riparian communities and exclude intensively managed agriculture. Subpopulations of interest to EMAP-Arid include the following formation types: desertscrub, grasslands, scrubland, woodland, tundra, riparian forrest, riparian scrub, and strandland. For the pilot study, sampling will be restricted to those sites that fall within the Great Basin Desertscrub or Great Basin Conifer Woodland formation types. Great Basin Desertscrub is characterized by low, widely spaced hemispherical shrubs with the major dominants being sagebrushes, saltbushes, and winterfat. Great Basin Conifer Woodland is characterized by the unequal dominance of openly spaced juniper and pinyon trees that rarely exceed 12 m in height.

The sample plot design (Figure 3) is a unified whole that encompasses the particular sampling design components for each of the individual indicator category measurements discussed below. The four circular subplots (MD, A1, B1, C1) upon which trees and shrubs > 1.5 m in height will be measured were designed to be compatible with the plot design employed by EMAP-Forest.

## Indicators

### *Introduction*

Indicators are associated with assessment endpoints and societal values through a conceptual model. This provides the framework for indicator development that was employed during a series of workshops to identify candidate indicators that relate to the issues of sustainability, biodiversity, and aesthetics. These candidate indicators were then evaluated in a K-T analysis to select those that would be tested in the pilot study. Those selected include spectral properties; vegetation composition, structure, and abundance; and soil properties including erosion indices.

### *Spectral Properties Indicators*

Vegetation and soils reflect light in specific and characteristic patterns that depend on a variety of factors including their composition, moisture content, shadowing, presence of other materials, etc. These

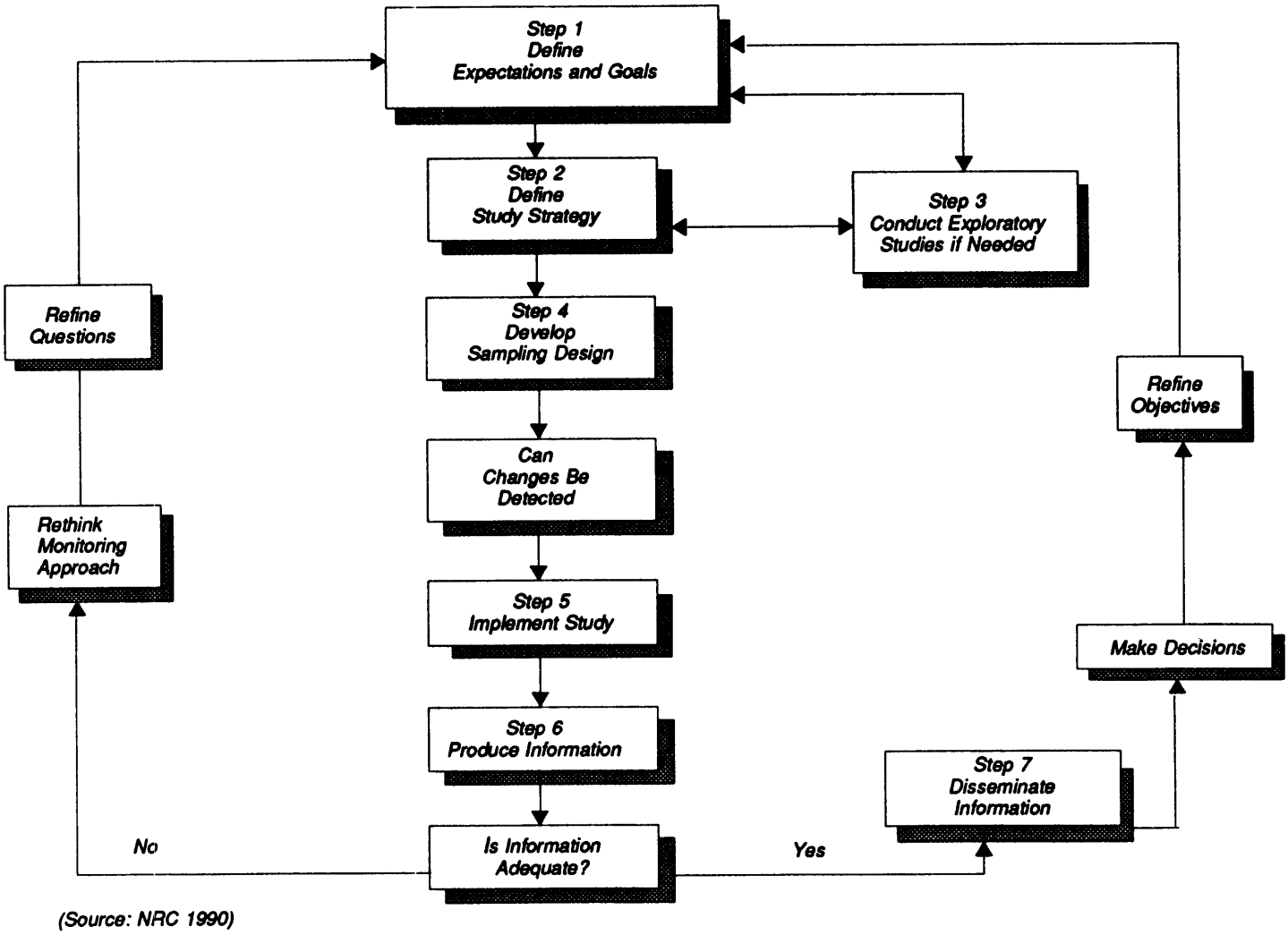


***Figure 1.*** *Elements of designing and implementing a monitoring program.*

characteristic patterns of the reflected light can be determined from the spectra recorded by either ground-based spectrometers or by various sensors on remote platforms including satellites.

The pilot study will examine spectra from remote platforms including the Advanced Very High Resolution Radiometer (AVHRR), Multispectral Scanner (MSS) and Thematic Mapper (TM). A personal spectrometer will be used on the sites to collect ground-based spectra from the six vegetation transects (radial and external) and seven circular subplots (Figure 3). During the field season a catalogue of spectra from plant species and soil types encountered will also be developed.

The spectral properties category of indicators is designed to examine the relationships between remote sensing measurements and ecological variables determined from ground-based measurements.

## Vegetation Composition, Structure, and Abundance

The composition, structure, and abundance of vegetation have been recognized as useful indicators of environmentally induced changes in arid ecosystems. Data for trees and shrubs <1.5 m in height will be recorded for twelve quadrats located along each of the radial and exterior transects (Figure 3). Within these quadrats are 20 x 50 cm subquadrats where species composition and vegetation cover and height will be recorded for grasses and forbs. In conjunction with the vegetation measurements in these subquadrats, data will be collected on the surface features of the site (rock fragment size and distribution, percentage bare soil, litter cover, etc.). These surface features data will be used with soil properties indicators in determining soil erosion estimates. The species identification, height, trunk diameter and crown diameters (longest and the perpendicular) will be recorded for trees and shrubs >1.5 m in height in the four circular subplots (A1, B1, C1, and MD, Figure 3).

## Soil Properties

Soil properties influence the amount of moisture and nutrients available for plant growth, the vertical and horizontal movement of moisture and nutrients through ecosystems, and transportation of sus-

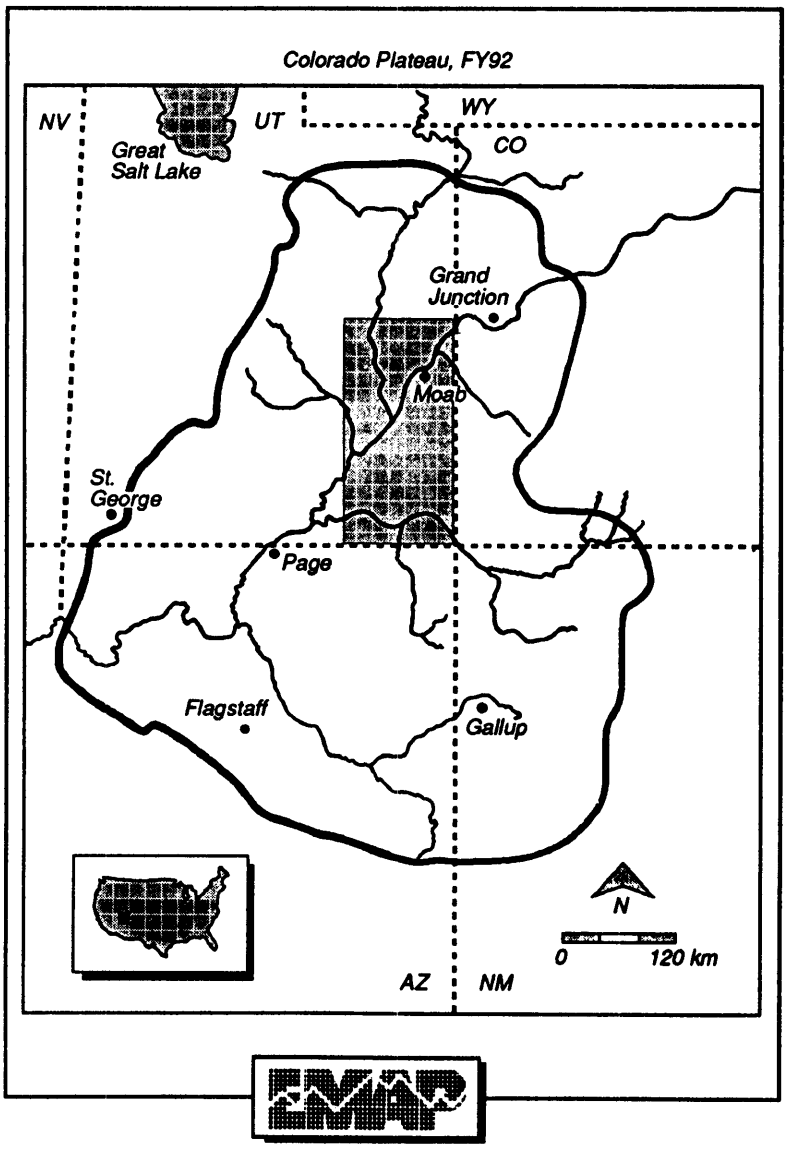


*Figure 2. Map of the Colorado Plateau.*

pended and dissolved solids into neighboring water bodies. Thus, soil properties are important in interpreting results of vegetation measurements and are themselves subject to change. At half of the sites, a complete soil profile will be described from a pit dug to 1.5 m or bedrock. Each horizon present in these soil pits will be sampled. In addition, surface soils will be described from two pits dug to 50 cm, with samples collected from the top two horizons. At the other half of the sites, three surface soil pits will be dug and sampled. All soil samples will be sent to the SCS Lincoln Soil Laboratory for complete analysis of physical and chemical properties.

## Logistics

Logistics include all the activities necessary to plan and implement the pilot study including obtaining site access permission, scheduling, training, shipping samples, data and sample tracking, communications, and providing support to the field sampling crews. Each field sampling crew consists of a field supervisor, soil scientist, botanist, spectrometer technician, and field technician, each with specific responsibilities during the sampling activities. A flow chart briefly describing the daily activities involved in the approximately eight-week field component of the pilot is given in Figure 4. Access to sites where permission of the owner has been granted will be by four wheel drive vehicle, hiking, helicopter, or a combination of these. The pilot will determine the logistic requirements for the upcoming demonstration study, including the special requirements of sampling with interagency teams. The logistical details of the pilot study are fully described in the Field Operations and Training Manual.

## Quality Assurance

Quality assurance (QA) for EMAP-Arid is based on a philosophy of guidance and assistance rather than enforcement. The goal of QA is to ensure that the type, amount, and quality of the field data collected are adequate to meet the objectives of the study. The Quality Assurance Project Plan is a part of the Field Operations and Training Manual, but the Implementation Plan gives an overview of the QA activities for the pilot. Key activities include crew comparability and resampling repeatability studies, field audits to ensure protocols are being followed, and duplicate soil sampling as a quality assurance check on the laboratory analyses. After the pilot, the activities will include working with the indicator leads to develop data quality objectives for the demonstration study.

## Information Management and GIS

Information management for the pilot study involves five main functions: prefield planning and preparation; field activities; central office activities; external data set acquisition; and data assimilation, review, and assessment. Thus, data are managed from development of data entry forms through collection and use in analysis and reporting. Programs will be developed and tested for personal data recorders to allow electronic data entry in the field for the vegetation measurements.

## Analysis and Reporting

The focus of EMAP-Arid Colorado Plateau Pilot Study is to evaluate selected indicators and the logistical, QA, and information management requirements of implementing them. This evaluation will rely heavily on statistical analysis of the variance components of each measurement and indicator but will also include other statistical analyses and subjective considerations. The approach will be to answer each specific question formulated to address the objectives of the pilot study. The results will be incorporated into a report on the pilot study and used to plan future demonstration and pilot studies.

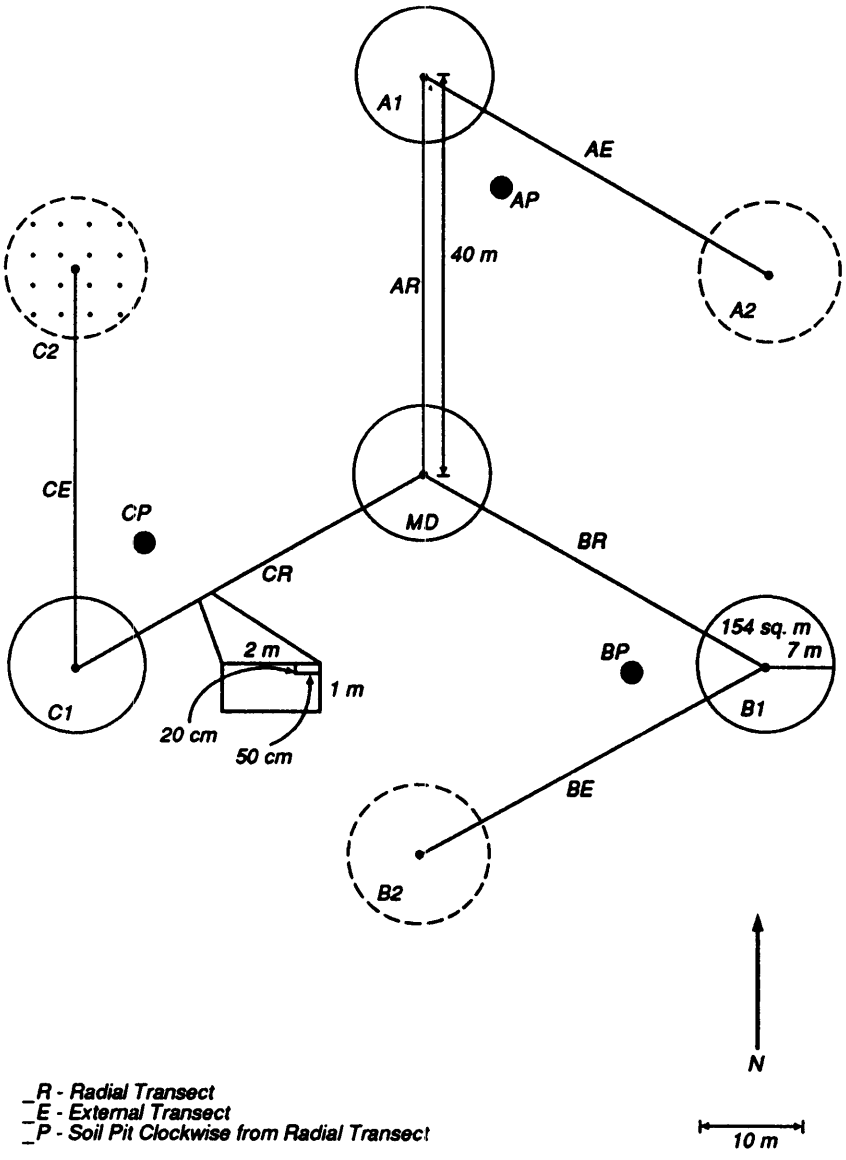


*Figure 3. EMAP-Arid sample plot design.*

## Candidate Indicators

During the discussions and workshops, several categories of indicators in addition to those being tested in the 1992 pilot were proposed that have great promise for monitoring arid ecosystem condition. Two of these indicator categories, landscape and retrospective history, have parameters that can be determined in part from existing data or data already being collected in the pilot study as part of other indicator measurements, and could be developed for the pilot study after the field season, should funding allow. Landscape indicators being considered include habitat/cover type proportions, spatial distribution of agriculture and riparian vegetation per stream reach, fractal dimension, abundance/density of key physical features, spatial distribution of grazing intensity, and riparian condition. Retrospective indicators being considered include tree-ring series, meteorological data, pollen records, packrat middens, and fossil charcoal records.

## Conclusions

The EMAP-Arid Colorado Pilot Study - 1992 Implementation Plan presents a description of the activities of the EMAP-Arid group during the summer of 1992. Details of the objectives of the pilot study, rationale for study site and indicator selection, sampling design, logistics, quality assurance, information management, analysis and reporting, and the individual indicators to be measured are presented in the Implementation Plan. A companion document, the Field Operations and Training Manual, has been prepared to augment the information provided in the Implementation Plan and provides greater detail on field sampling methods, safety, and quality assurance.

The pilot study will apply the EMAP design to arid ecosystems in an effort to evaluate candidate indicators of arid ecosystem condition. The pilot is an interagency effort involving EPA, BLM, NPS, FS, SCS, FWS, and the Navajo and Ute Nations. Special logistical requirements resulting from this interagency effort will be evaluated along with the indicators. The results of this pilot study will provide information for future development of the EMAP-Arid program.

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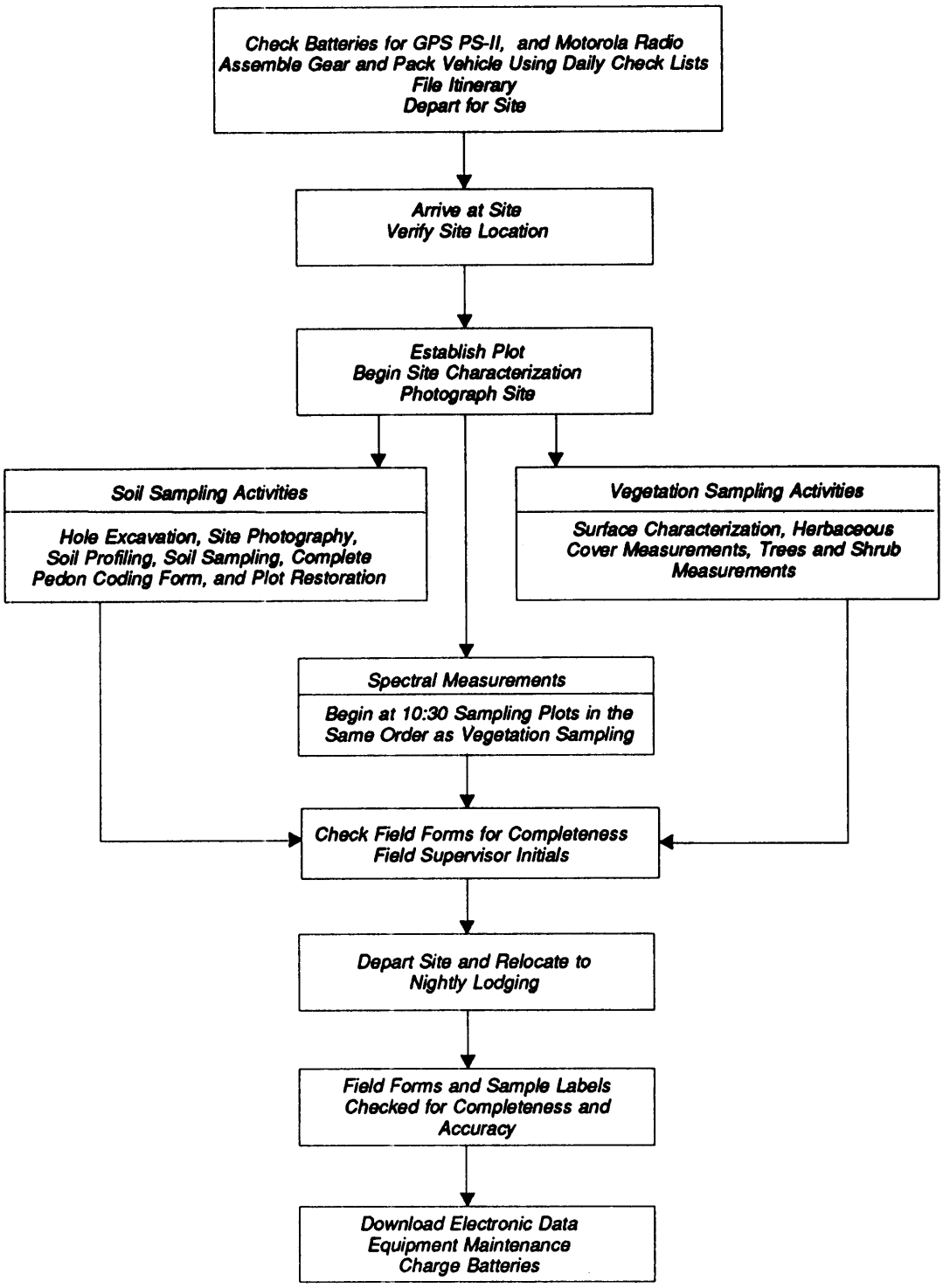


***Figure 4.*** *Flow chart of daily activities.*



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*The EPA Editor,* ***Susan E. Franson,*** *is with the Environmental Monitoring Systems Laboratory, Las Vegas, NV 89193-3478.*

***William G. Kepner*** *is the EPA Project Officer (see below).*

*The complete report, entitled "Environmental Monitoring and Assessment Program: EMAP-Arid Colorado Plateau Pilot Study - 1992: Implementation Plan," (Order No. PB93-181 618/AS; Cost: $27.00, subject to change) will be available only from:*

*National Technical Information Service*
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