

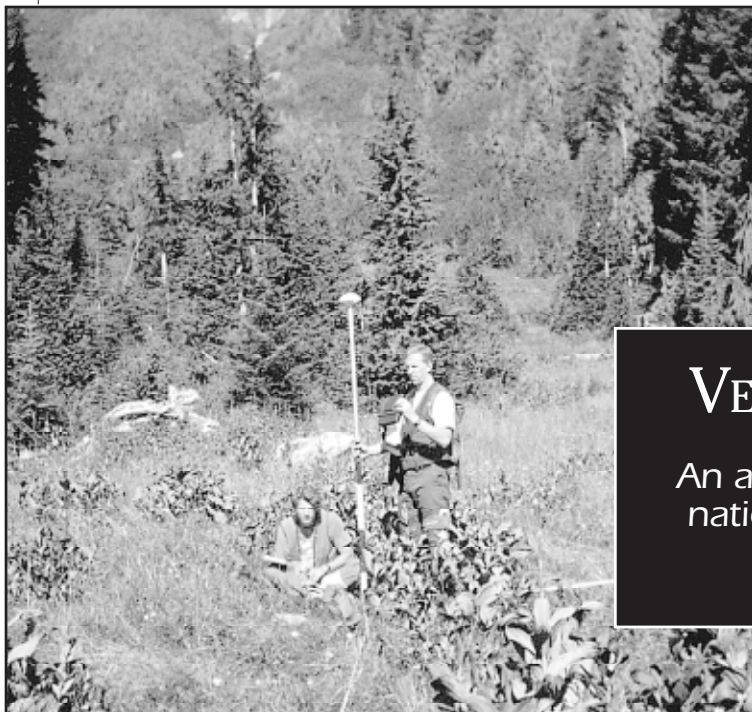


Figure 1. Pacific Meridian Resources personnel Ron Diver and Jeff Campbell (standing) collect vegetation data georeferenced by a global positioning system in the Low Divide area of Olympic National Park, Washington.

## VEGETATION MAPPING IN NORTHWESTERN

An ambitious project to develop a regional GIS database for national parks to develop interagency partnerships for management based on scientific principles

By June C. Rugh, David L. Peterson, and Jeff T. Campbell

**H**ow much old-growth forest remains for the northern spotted owl in the Pacific Northwest? What proportion of land area in each park is occupied by alpine vegetation? Which watershed has the largest percentage of Douglas fir crown cover?

These are questions that managers in Crater Lake, Mount Rainier, North Cascades, and Olympic National Parks will soon be able to answer with unprecedented accuracy, consistency, and state of the art documentation. The Columbi-Cascades System Support Office is working with Pacific Meridian Resources, Inc., to develop a comprehensive GIS database of vegetative, topographic, and landform data layers. Due for completion in September 1995, this database will increase our knowledge of ecosystems in the four parks, greatly enhancing resource managers' abilities to organize data, analyze relationships between resources in a spatial context, and assess the potential impacts of management decisions.

Until now, the rugged and remote landscapes characteristic of these parks have limited scientists in developing detailed, comprehensive data on vegetation and landforms. Pacific Meridian Resources is tackling this challenge by integrating existing monitoring and research data, extensive field reconnaissance, aerial photography, and satellite imagery into the

regional GIS database. Using the various scales and resolutions of each of these database types, Pacific Meridian can obtain detailed information from more easily accessible areas. The detail can then be extrapolated to describe areas in remote locations determined to be similar from the satellite imagery and aerial photography. A GIS database encompassing all regions of the park will result.

Generally speaking, GIS databases describe the physical, biological, and cultural attributes of resources. They link computerized maps (location data) to computerized databases that describe the attributes of a particular location. This link makes possible simultaneous access to both location and attribute data for simulating the effects of management and policy alternatives. GISs are powerful tools, because a single operator can quickly search, display, analyze, and model spatial information. Moreover, maps and data can be updated more rapidly and accurately than with conventional methods.

The core of the Pacific Northwest project is an ecosystem database that focuses on two primary components: 1) characterization of forested and nonforested vegetative types across all park areas, as defined by criteria such as tree species, stem density,

stand age, crown cover by species, dominant understory species in forested areas, and species cover in nonforested areas; and 2) characterization of topography and landforms, including development of data layers for slope, aspect, elevation, and landform type.

What makes the Pacific Northwest project different from others? After all, many national parks have descriptions of physical and biological components, with some already in digital GIS format. First, the innovative use of remote sensing technology will produce a detailed description of multiresource landscapes, allowing resource managers to address issues in an ecosystem context. This dynamic, spatial database will enable managers to assess forest stand dynamics and wildlife habitat with accuracy and thoroughness. Second, the database will provide a comprehensive framework on which more extensive and detailed information can be built, and which will be consistent from park to park. Most significantly, the project demonstrates a regional approach to ecosystem management by organizing data from the four parks into one contiguous database and by coordinating efforts with adjacent land managers—

the U.S. Forest Service, state resource management agencies, and private timber companies.

The use of satellite image classification facilitates the regional approach to GIS database development. Satellite imagery not only provides detailed, consistent information about NPS lands of interest, but also presents the same detail and consistency

of information for lands adjacent to the parks. This insures compatibility between databases among different agencies, which in turn allows for greater potential in data sharing and collaborative resource management. Moreover, this cooperation reflects an increasing commitment on the part of resource man-

agers to cross political boundaries in order to achieve common goals.

#### THE TECHNICAL APPROACH

The technological hub of the project is a multistage sampling process. The process integrates existing data sources, new field data collection (fig. 1), Landsat Thematic Mapper satellite imagery, aerial photography, digital topographic data and other existing GIS data layers, and the knowledge and experience of Pacific Northwest ecology found within the Pacific Meridian project team and NPS staff. Database design involves two steps: 1) identifying database standards for both spatial and classification accuracy and 2) developing a preliminary classification system that identifies the types of variation in vegetation and landforms of interest to the anticipated database users.

Spatial or positional accuracy is defined as the expected deviance in the geographic location of an object in the database from its true ground position. The spatial database standards for this project will be largely a function of the scale and resolution of various data ranging from 30 m (33 yd) Landsat Thematic Mapping imagery and digital elevation data to 1:100,000 and 1:500,000 scale geology

map data. All data will be coregistered with the satellite imagery to ensure spatial consistency. Classification accuracy is the probability that the class assigned to a particular location on the map is the same class that would be found at that location in the field. While traditional classification standards imply only true or false classifications, Pacific Meridian is working with NPS staff to incorporate *fuzzy sets* (flexible criteria) into accuracy standards, deriving a set of measures to analyze the nature, frequency, source and relative magnitude of map errors. This will provide us with more complete information on map reliability.

In developing the classification system, landforms are characterized by slope, aspect, elevation, and landform type, including substrata origin and type (such as bedrock type). Landform identification can be highly variable and can range from general descriptions of topographic shapes (mountain, plateau) to specific terms indicating depositional form and process (alluvial fan, glacial moraine). This project is producing a digital geomorphic landform layer that describes substrate origin and type.

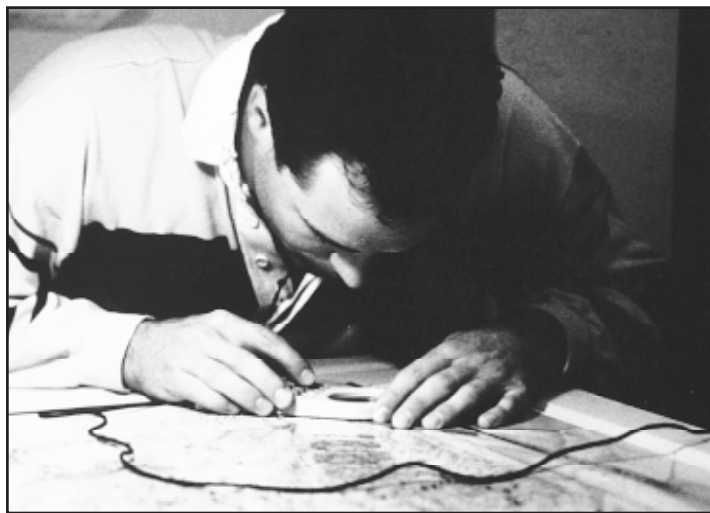


*Figure 2. Traditionally, landscape information is transferred from hardcopy maps and photos to the GIS through the painstaking process of digitizing. Contractor Pacific Meridian is investigating using a digital shaded relief data technique that would eliminate many of the hardcopy transfer steps.*

Landform data can be developed through a variety of methodologies ranging from extensive field reconnaissance to digital data modeling to photo interpretation. The method deemed most efficient and suitable for this project is the interpre-

tation of high altitude aerial photography and topographic base map data. We will interpret landforms from 1:80,000 scale National High Altitude Aerial Photography (NHAAP) and delineated directly onto 1:100,000 scale topographic maps. Interpretation will be aided by review of both the topographic maps and local geologic maps.

Pacific Meridian is also investigating the use of digital shaded relief data developed from 1:24,000 digital elevation area draped with satellite imagery. The digital images could be interpreted with the assistance of NHAAP photography and previously collected field data. Landform characteristics could then be delineated directly on the computer screen. This methodology would eliminate the need for many of the hardcopy transfer and digitizing steps required in the strictly photo-interpreted landform mapping methodology (fig. 2). Where feasible, landform classes will be verified during field reconnaissance efforts associated with the vegetation database development phase of the project. Based on scale limitations of the source data, the minimum mapping unit for landforms will be approximately 40 ha (99 acres).

We will characterize vegetation by several variables: stem density by tree species, stand age by species, tree diameter by tree species, crown diameter by tree species, crown cover by tree species, standing dead trees, dominant understory species in forested areas, and cover of herbaceous plant species in nonforested areas. In developing the vegetation characteristics database, we will use satellite images as a basis for determining the vegetation data themes through the integration of various ancillary data sources. The reason remotely sensed data (such as satellite imagery or aerial photography) can be used to collect vegetation information is because of the high correlation between variation in imagery and actual variation in vegetation.

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Remotely sensed data is particularly effective for mapping the variation in tree canopy characteristics (such as crown diameter by species, crown closure by species) in forested areas, and the soil type, moisture, and nontree vegetation variation in nonforested areas (fig. 3). Thus, satellite imagery can be useful in characterizing much of the variation in vegetation across the national parks. Landform classes will be digitized directly from the topographic maps to form the final landform type layer. Furthermore, land cover classification data from satellite imagery can provide much more detailed intensive information than results from traditional photo-interpreted polygon classifications. For example, while a 5-ha polygon may summarize forest age, canopy cover, structure, and so on, satellite image classification provides information on the variation of forest age, canopy cover, structure, and so on without the 5-ha polygon area.

Vegetation characteristics that cannot be directly mapped from the imagery can be delineated through the development of relationships among the imagery, fire history, and landform characteristics. For example, tree diameter, which cannot be mapped from aerial photos or satellite imagery, is highly correlated with tree canopy diameter, which can be estimated from remotely sensed data. In addition, a multistage sampling process is used to determine the relationships of the imagery of forest canopy characteristics

to nonforest cover types; canopy characteristics to subcanopy characteristics; and landform, fire history, and other environmental factors to forest canopy characteristics, forest subcanopy characteristics, and nonforest cover types. Multistage sampling employs the fact that strong relationships exist between some characteristics that are inexpensive to estimate (such as crown diameter) and other variables costly to estimate (such as tree diameter). We will use

the combinations of these relationships to develop the database of vegetation characteristics.

Quantitative assessment of map classification accuracy involves comparing the map to reference data (from photo interpretation or field identification, for example), which is assumed to be correct. Because comparison of every spatial point is impractical, sample comparisons are used to estimate the accuracy of maps. Accuracy assessment requires: 1) the design of unbiased and consistent sampling and photo interpretation and field procedures, and 2) rigorous analysis of the sample data. We are using strict quality control and quality assurance procedures in both data collection and subsequent analysis to insure accuracy in the final dataset.

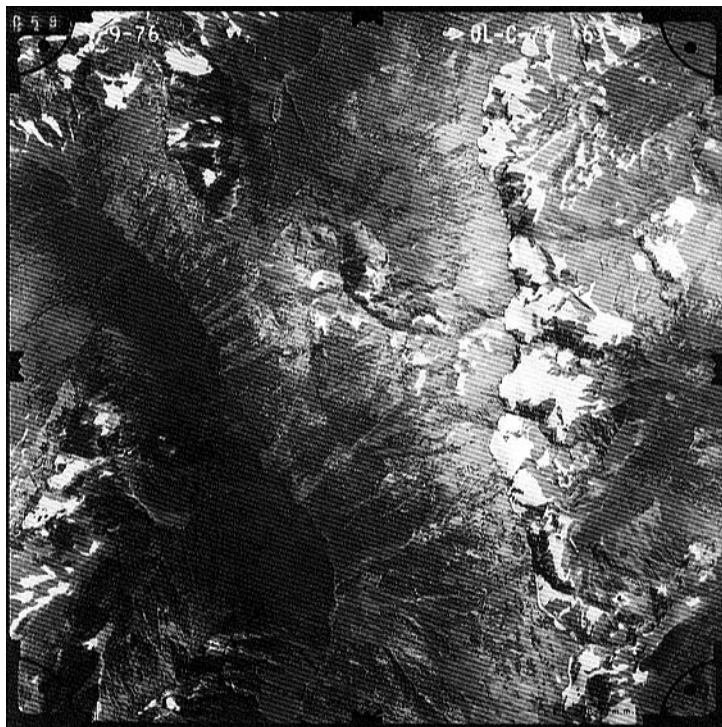


*Figure 3. High altitude photographs, like this 1:24,000 scale photograph of Olympic National Park, show contrasts in vegetation types and landforms, and can be used to help GIS production staff classify vegetation.*

#### **LOOKING AHEAD**

The vegetation mapping project currently underway in the Pacific Northwest is an important component of regional programs in inventory and monitoring, resource management, and science. It will also provide information for a wide range of uses. The new database will be a high-quality template for monitoring the condition of natural resources. It will provide a geographically based link to various disci-

plines within resource management, such as wildlife, hydrology, and fire. The database will also be an important tool for research scientists in identifying specific vegetative and geomorphic resources, and for georeferencing all future scientific activities in the parks.

The database will provide a framework for increased and more specific cooperation with other agencies and institutions. Ecosystems do not stop at park boundaries, and water and wildlife resources cross these boundaries freely. The availability of a consistent, compatible database will allow national parks to develop interagency partnerships for ecosystem management based on scientific principles. Broader landscape-regional assessments and management strategies will now be possible.

Furthermore, the Columbia-Cascades Cluster will be able to cooperate in other similar vegetation efforts (planned or under way) by the National Park Service, National Biological Service, and other agencies.

Ecosystems are constantly changing—sometimes gradually, sometimes abruptly. The new database will be dynamic in order to track spatial and temporal changes in park natural resources, and it will facilitate continual updating over time. It will allow park managers and scientists to determine the influence of large-scale disturbances, such as fire, on park landscapes, and the potential impacts of long-term phenomena, such as climate change. Other uses, not yet envisioned, will certainly develop. The new database will be more than a mere vegetation map—it will be a powerful

managerial and scientific tool for many years to come.

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