Indicator Development for Landscape-Level Aquatic Ecological Vulnerability Assessment in Western United States

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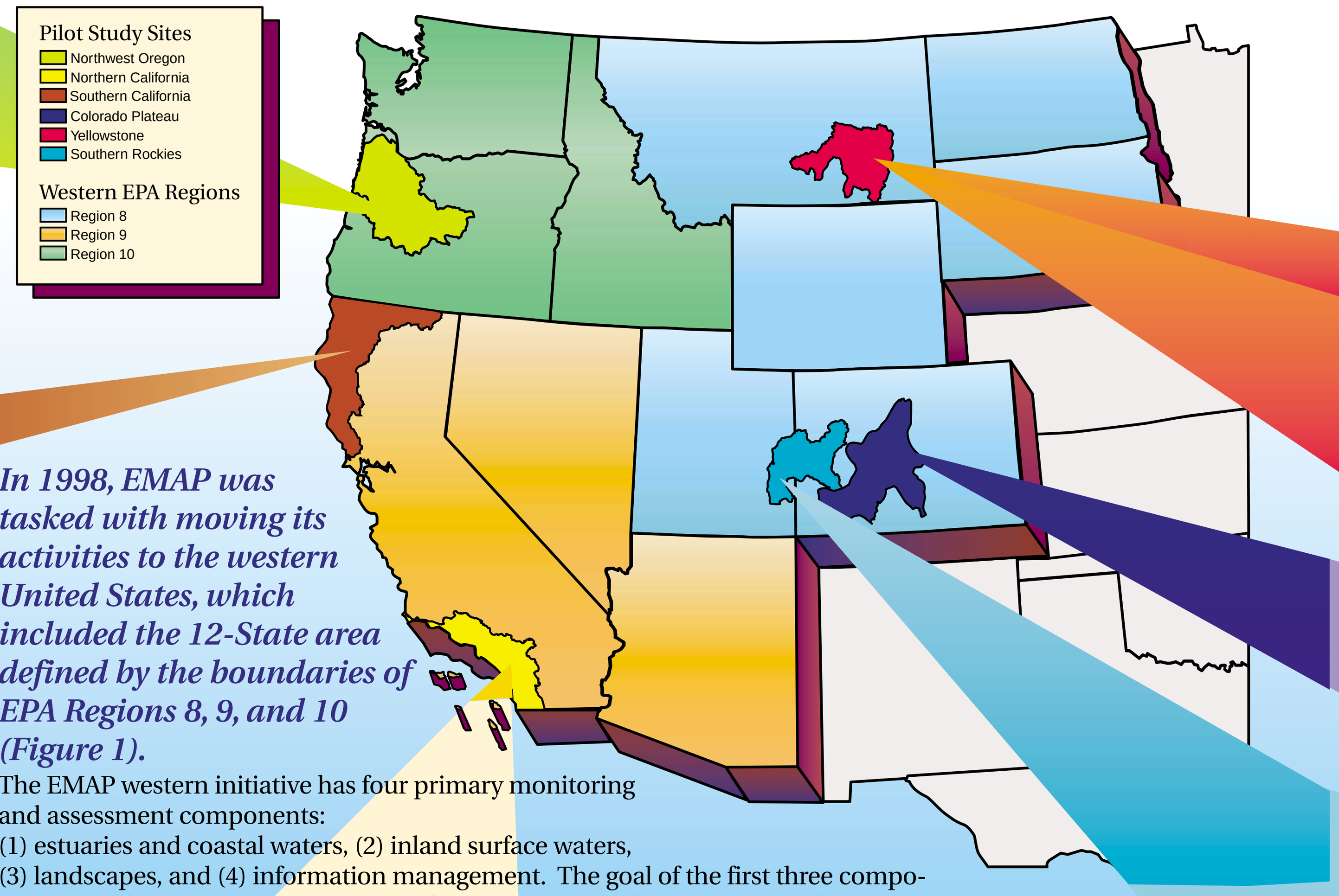
Abstract

The Environmental Monitoring and Assessment Program (EMAP) is proposing an ambitious agenda to assess the status of aquatic resources in a 12-State area of the western United States by 2003.
Additionally, EMAP is proposing to access landscape conditions as they relate to aquatic resources with the aim of extending probability-based sampling to all streams, estuaries, and coastal waters across the western US. Five research and development activities are critical to the completion of this unprecedented landscape assessment: (1) acquisition and assembly of landscape databases, (2) developing new remote sensing approaches to detect watershed-scale stressors, (3) identifying and developing landscape indicators, (4) quantifying relationships between aquatic resource conditions and landscape indicators, and (5) developing and implementing assessment methodologies. Results of the assessment should help environmental managers target those areas where aquatic resources are most vulnerable to decline in conditions based on watershed-scale, landscape conditions. This poster presentation gives the results of the first application of landscape ecological indicators to selected areas in the western United States.

Introduction

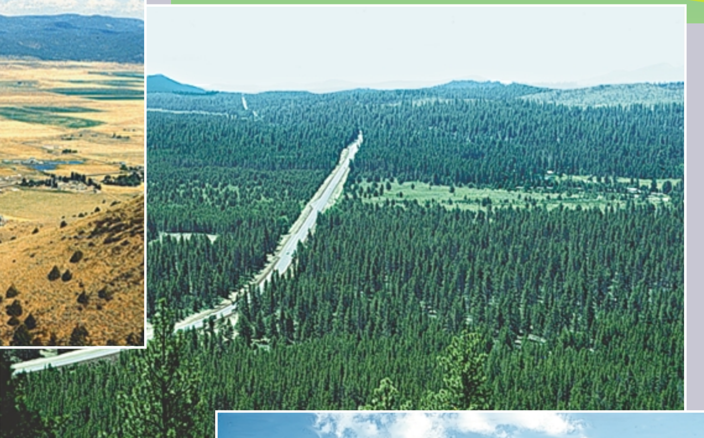
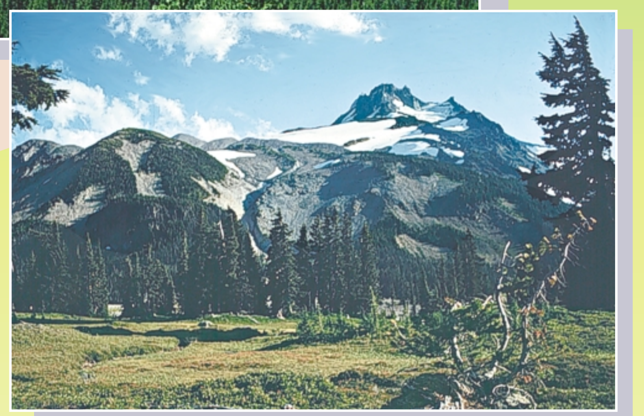
There is a growing interest among Federal agencies, States, and the public to evaluate environmental conditions at community, watershed, regional, and national scales.
The relatively high cost of collecting environmental data has limited the implementation of regional- and national-scale monitoring programs. In 1996, a regional-scale land-cover database was developed for the five-state area of the United States Mid-Atlantic Region, and this database, along with other regional landscape coverages (e.g., topography, soils, road networks, stream networks, and human population density), was used to assess landscape conditions across the entire region down to a scale of 30 meters (Jones et al., 1997). The assessment used a set of landscape indicators (O'Neill et al., 1988, 1997) to evaluate the spatial patterns of human-induced stresses and the spatial arrangement of forest, forest-edge, and riparian habitats as they influence forest habitat suitability and aquatic resources. Advances in computer technology and geographic information systems (GIS) have made it possible to calculate landscape metrics over large areas (e.g., regions) at relatively fine scales. As a result, this information can be used to develop multi-scale plans to reduce vulnerability or risk and prioritize activities to restore ecological function, condition, and sustainability.

Western EMAP Landscape Assessment Areas

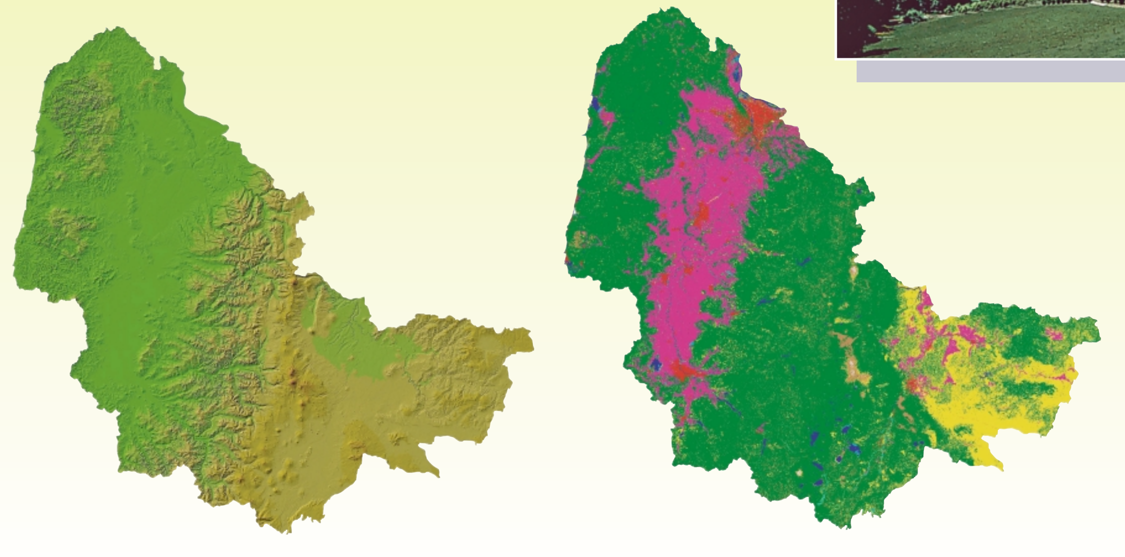


In 1998, EMAP was tasked with moving its activities to the western United States, which included the 12-State area defined by the boundaries of EPA Regions 8, 9, and 10 (Figure 1).
The EMAP western initiative has four primary monitoring and assessment components:
(1) estuaries and coastal waters, (2) inland surface waters,
(3) landscapes, and (4) information management. The goal of the first three components is to demonstrate monitoring techniques and sampling designs, and to conduct an assessment across the entire 12-State area. The landscape component is tasked with assessing spatial variability in landscape pattern and the degree to which landscape pattern influences the conditions of estuaries, coastal waters, and in-land surface waters at watershed scales. If conditions in aquatic resources are closely linked to watershed-scale, landscape patterns, then it may be possible to assess potential conditions of aquatic resources from landscape data at many scales across the western US. This is made possible because the new set of landscape data being generated (see discussion above) will cover the entire surface of the western US at relatively fine scales (30 meters). Potentially, this could be a significant augmentation to aquatic resource assessments because funds limit the number of streams, coastal waters, and estuaries that can be sampled. Another use of the assessment would be to target areas where aquatic resources are at greatest risk of decline (see Jones et al., 1997; Wickham et al., 1999).
The western US presents a set of additional problems not encountered in the work in the mid-Atlantic Region of the US. First, land cover and vegetation in the western US is considerably more diverse than in the mid-Atlantic; this will present a challenge in developing and interpreting landscape indicators. Second, the study area is many times larger than the mid-Atlantic and will present a significant challenge in the processing of data. Finally, there are a number of stresses on western landscapes, including grazing and timber harvest, that do not result in changes in land cover types, but rather in degraded states of land cover conditions. New remote sensing data and analytical approaches are needed to determine the extent and magnitude of these stresses.
Pilot areas across the western US were chosen to start the landscape indicator selection and development process. Pilot areas were selected on the basis of high ecological priority to the EPA Region, availability of aquatic data, availability of landscape data and to capture different biophysical settings where relationships between the landscape and aquatic conditions are likely to be different. Once tested in pilot areas, indicators may then be applied to the States, Regions, and finally the entire western US.
The Western EMAP landscape assessment will focus on the influence of landscape pattern on aquatic resources because EPA has a primary responsibility in assuring the protection of water resources. However, the landscape approach evaluates many aspects of the terrestrial environment because these attributes are intricately linked to ecological and hydrological processes that influence aquatic resource conditions, as predicted from Ecological Hierarchy Theory (O'Neill et al., 1986).
Due to gaps in our understanding of landscapes and their influence on aquatic resources, it will be necessary to implement a set of research and development projects to achieve the overall goal of a western landscape assessment relative to aquatic resources. This poster presentation gives the results of the first application of landscape ecological indicators to selected areas in the western United States.

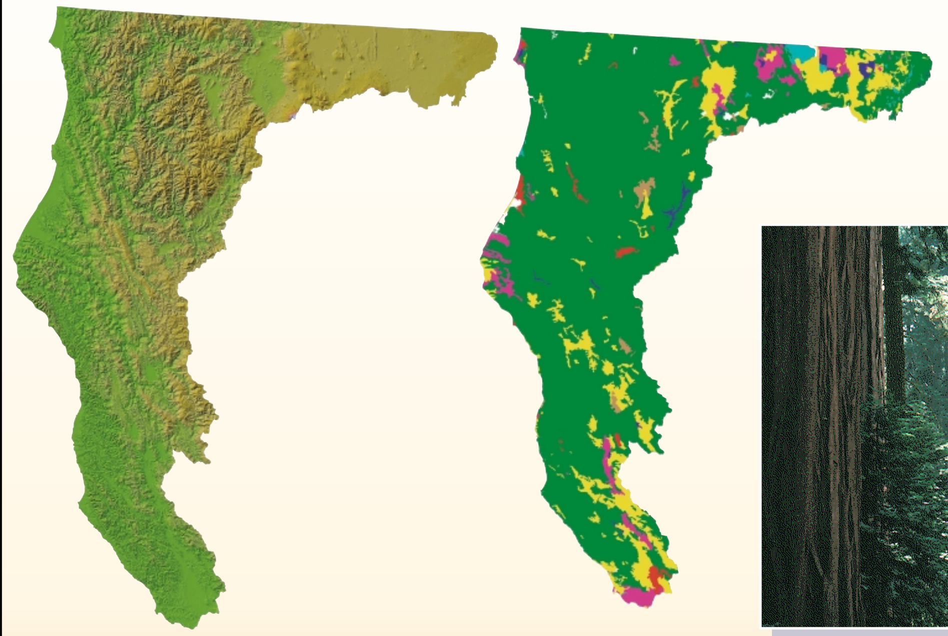
Northwest Oregon Study Area


The Northwest Oregon study area is approximately 52,400 km^2 in size and ranges from sea level to 3200 m. It includes the north Coast Range Mountains, the Willamette Valley, the north Oregon Cascades, and the upper Deschutes River Basin. This extremely diverse landscape consists of coastal plains, temperate rain forests, intensive agricultural areas, and sparsely vegetated shrub lands. It also includes the large urban area of Portland, the fast growing city of Bend, and uninhabited desert and alpine environments. The economic base is primarily derived from agriculture, tourism and forest products. Water resources are impacted negatively by sediment accumulation, temperature increases, and high concentrations of bacteria. The contributing factors include grazing, irrigated and nonirrigated agriculture, logging, and urban growth.

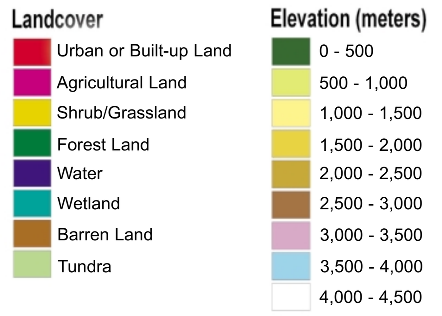


Northern California Study Area



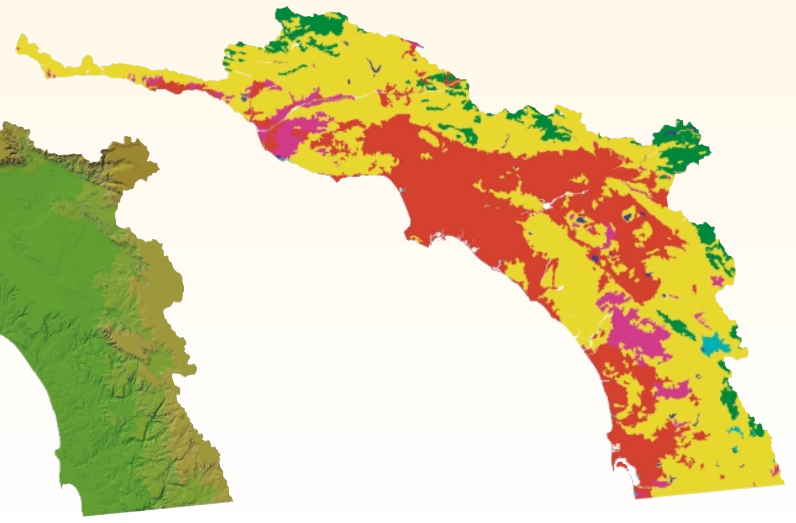
The Northern California study area is approximately 50,600 km^2 in size and consists of the watersheds draining to the Pacific Ocean between the Tomales Bay and the Oregon border. This is an area of relatively low population density with land use practices dominated by forestry and agriculture. Northern California streams and rivers are degraded primarily by increased sedimentation and temperature. Elevations range from sea level to 4300 m.

Landcover information for the pilot areas was obtained from the Montana GAP Program, University of Montana, the Colorado GAP Program, Colorado Division of Wildlife, the Utah GAP Program, Utah State University, the California GAP Analysis Project, Biogeography Laboratory, University of California Santa Barbara, and the MRLC Regional Land Cover Characterization Project, USGS EROS Data Center (EDC), Sioux Falls, South Dakota.



Southern California Study Area

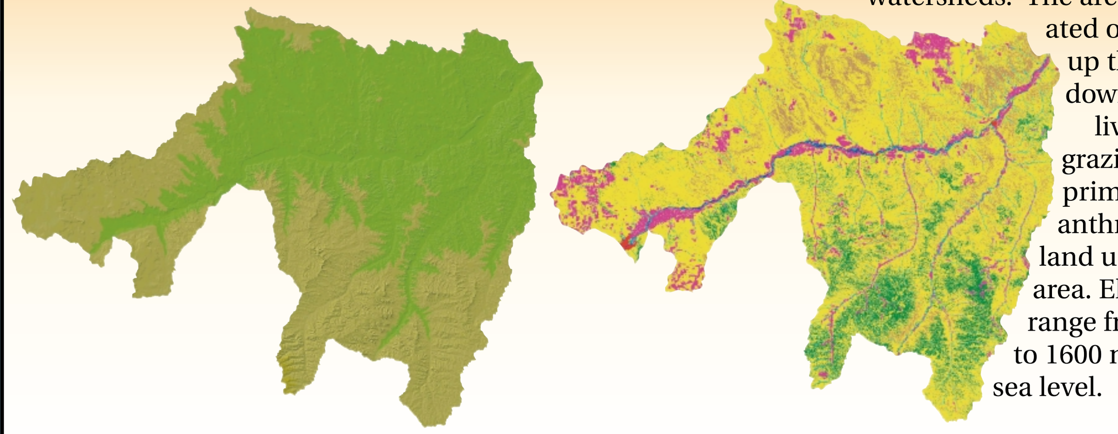




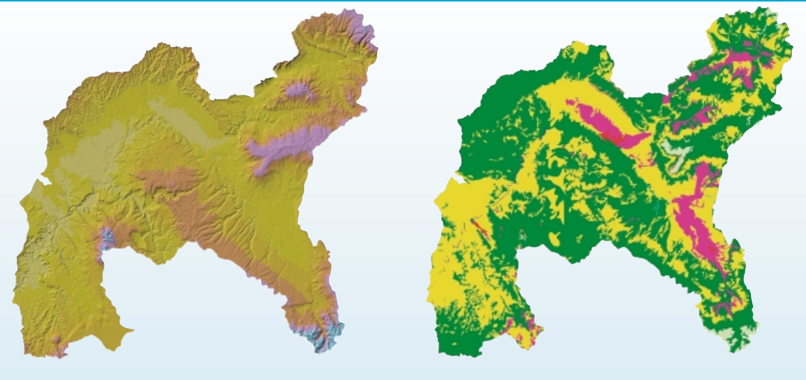
The Southern California study area is approximately 29,400 km^2 in size and comprises the watersheds draining into the Southern California Bight from the U.S.-Mexico Border to Point Conception. Much of this area is highly urbanized and experiencing rapid population growth.
The trend has been toward suburbanization of agricultural land and transformation of undisturbed habitats to agricultural uses. In addition to pollutant inputs associated with urbanization and agricultural development, channelization of natural streams and alterations of natural flow patterns have degraded stream quality. Elevations range from sea level to 2550 m.

Lower Yellowstone Study Area

The Lower Yellowstone study area in Eastern Montana is approximately 30,700 km^2 in size and is dominated by the grasslands and rangelands that are characteristic of the Northern Great Plains. The study area is predominately rural and is defined by the lower Yellowstone River and its riparian zone and associated watersheds. The area includes Billings, Montana, which is situated on the western edge. Watersheds that make up the study area feed into the Yellowstone downstream of Billings. Agriculture, including livestock grazing, is the primary anthropogenic land use in the area. Elevations range from 650 m to 1600 m above sea level.




Colorado Plateau Study Area



The Colorado Plateau study area is approximately 27,350 km^2 in size and ranges from some high mountain montane forests in Western Colorado to vast open canyon, rangeland, and desert areas of Southeastern Utah. The Colorado River from Glenwood Springs, Colorado downstream to the confluence with the Green River in Utah is the focus of the study area definition. Primary rivers that define some of the study area's watersheds include the Colorado, Gunnison, Uncompahgre, Dolores, and Green. Grand Junction, Colorado and Moab, Utah are included in the area, as are the intensively irrigated agricultural Grand and Uncompahgre Valleys. Elevations range from 1150 m to 4150 m above sea level.


Southern Rockies Study Area

The Southern Rockies study area is approximately 48,550 km^2 in size and is dominated by the mineralized portion of the Southern Rockies ecoregion (Omernik, 1987, 1993) in west central Colorado. The mountainous area includes most of the tallest peaks in Colorado and the valleys between ranges. The area varies between alpine tundra, montane forests, high elevation rangelands, and river valley riparian ecosystems. Former and present mining activity scars some of the landscape and affects water quality. Elevations for this area range from 1600 m to 4400 m above sea level.