10 ▪ Ecosystem and Watershed Management

Ecosystem management (EM) and watershed management (WSM) have emerged as holistic approaches to integrate the wide range of objectives and perspectives in environmental land planning and management. These two approaches share some common themes. They both aim to

- integrate science and politics;
- consider variable scales, telescoping to larger landscapes and zooming in to smaller sites (see figure 10.1);
- have a long-term time perspective, in terms of both process and outcomes;
- be scientifically based, using both initial "best science" assessment and long-term scientific learning;
- focus on ecological integrity and incorporate social and economic objectives;
- consider a wide range of regulatory and nonregulatory solutions and integrate them into a comprehensive strategy;
- engage stakeholders to tap scientific and local knowledge, perceptions, and values; and
- use monitoring and adaptive management to learn from implementation and fine-tune strategies.

This chapter first describes the basic principles of ecosystem management and watershed protection, including scientific assessments and integrating strategies and programs. The chapter then explores institutional arrangements for ecosystem and watershed management, and finally, presents recent applications of EM and WSM.

Principles of Ecosystem Management

Historically, we have managed environmental resources with a singular, reductionist approach. In nature, however, these resources are inextricably linked not only to each other but also to human activities. It makes sense to look at them as a

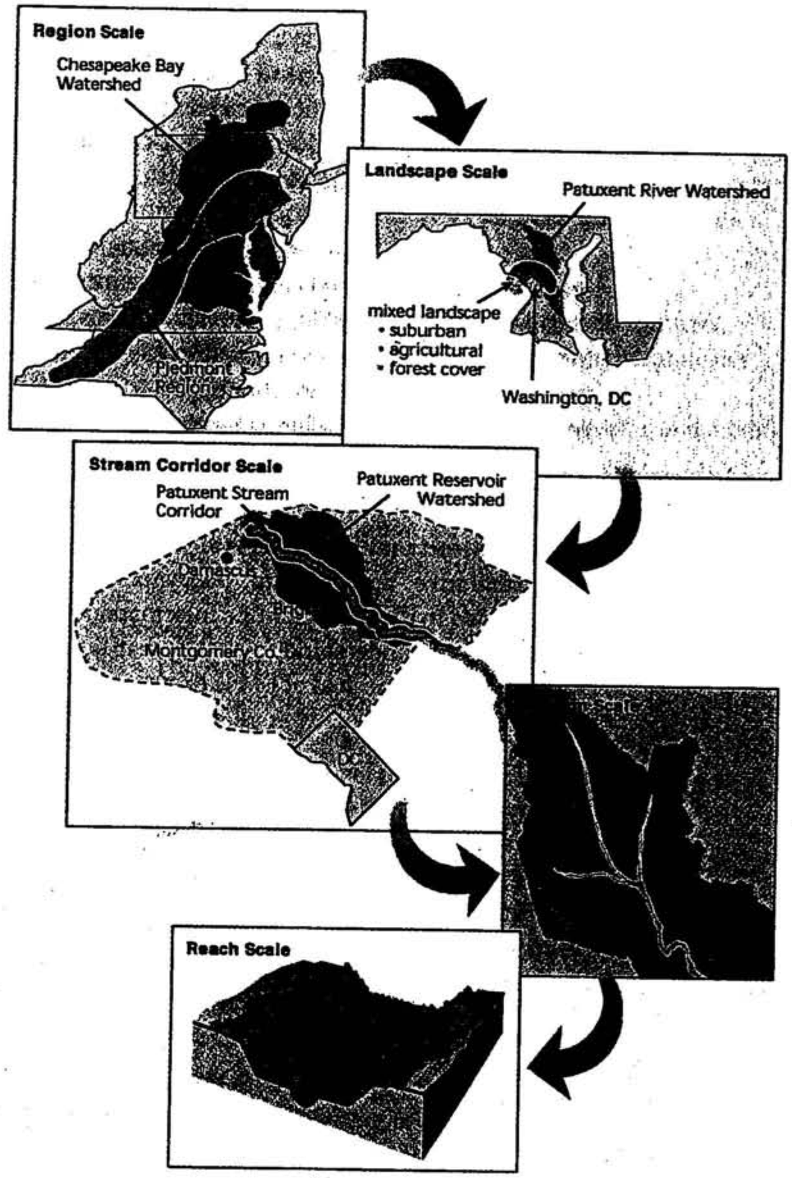


Figure 10.1 Ecosystem and Watershed Management Act across a Hierarchy of Scales. *Source:* FIWSCR (1998).

whole, to manage them as ecosystems. Ecosystems can be studied at a variety of scales, from an isolated tidal pool to a continent (figure 10.1). Human society is an important component and must be viewed as part of the ecosystem to be managed.

The current movement toward EM was prompted in the late 1980s by a number of converging factors, including the following:

- Heightened recognition of the "biodiversity crisis" of habitat destruction and species extinction

- Limited success of piecemeal environmental laws and programs in meeting the expectations of a range of stakeholders, including both development and preservation interests
- Theoretical and empirical developments in environmental management that called for more holistic and adaptive approaches
- Changing societal values and attitudes about natural systems, requiring new ways of incorporating those values in management

Since the early 1990s managing ecosystem integrity and health has become the operating policy of federal land management agencies, like the U.S. Forest Service and the U.S. Fish and Wildlife Service (Phillips and Randolph, 1998). It developed in response to concerns over biodiversity and the limitations of species-specific wildlife management and commodity-based resource management to ensure resource sustainability. The ecosystem approach has been adopted by many local and regional organizations for environmental management (Yaffee et al., 1996). As it has evolved during the 1990s, EM can be defined as follows:

Ecosystem management is an integrative, interdisciplinary, adaptive, and collaborative approach to policymaking, planning, and management, grounded in the best scientific information available, recognizing uncertainties, and the understanding that human activity and ecosystems are inextricably linked. The goal of EM is to sustain and/or restore ecosystem integrity and biological diversity at all spatial and temporal scales through scientific understanding and collaborative decision making.

The following list outlines five EM criteria. They include an ecological orientation; appropriate time and spatial scales; scientific data collection and analysis; a distinct role of humans in ecosystems and in planning and management; and appropriate interdisciplinary, interagency, and adaptive management actions (Grumbine, 1994; Phillips and Randolph, 2000; Smith, 1995).

Ecosystem Management Criteria

1. Ecological Orientation
   a. The ecosystem dictates use and management strategies.
   b. The integrity of the ecosystem is to be preserved in ways to seek sustainability.
   c. Natural biodiversity is to be maintained, focusing on how the biologic community functions as a whole within the ecosystem.
2. Time and Spatial Scale
   a. Long-term time horizon, looking at future generations of species including people.
   b. Boundaries are set by the ecosystem, not by jurisdictional borders.
   c. Hierarchy of ecosystem scales allows addressing larger landscape interconnections through site-scale actions.
3. Scientific Basis, Data Collection, and Analysis
   a. Acquire as complete a knowledge base as possible within technological, scientific, and budgetary limits.

   b. Use adaptive approaches to experiment and acquire new information to fill gaps in knowledge.
4. Role of Humans and Society
   a. Humans are part of ecosystems: Social, cultural, and economic values of humans must be considered in management of land and ecosystems;
   b. Humans have damaged the environment: Practice restoration.
   c. Humans will change the environment: Minimize and mitigate impact.
   d. Collaborative planning and decision making requires stakeholder involvement.
5. Management Actions
   a. Integrate management within agencies and between agencies.
   b. Integrate interdisciplinary practices into management strategies.
   c. Monitor management practices for effectiveness.
   d. Practice adaptive management: Learn from monitoring and modify practices as necessary.

The experience and experimentation in EM has been widespread. The approach has many well-accepted concepts. However, putting them into practice has proven difficult. Early experiments, such as the Greater Yellowstone Ecosystem program proved too complex to overcome political and interagency conflicts (Goldstein, 1992). The federal agencies have had problems institutionalizing the concepts of EM in their planning and management (Fitzsimmons, 1999). In addition, the principles have been applied in literally thousands of ecological and watershed restoration projects on private and public lands with mixed success.

Ecosystem Management on Public Lands

Ecosystem management did not enter the federal government vernacular until the early 1990s, but its roots go back much further. The organic acts of the national forest system (1891) and the national park system (1916) contain some of the principles of the "Ecosystem Management Criteria" list. The multiple use and sustained yield concepts of the 1950s and 1960s related to time and spatial scale and scientific analysis but were largely interpreted by the agencies to be a basis of commodity production rather than ecosystem integrity. However, the passage of the National Environmental Policy Act (NEPA) in 1970 and public lands planning legislation in the late 1970s, forced agencies to incorporate broader issues into their planning. Still, most efforts were procedural. It became clear that it is difficult to teach "old agency dogs" new tricks. It took some time before EM principles began to replace commodity production objectives in the Forest Service and the Bureau of Land Management and recreation interests in the Park Service. But, the agencies have been moving away from expert-driven, commodity/recreation-based, rational-comprehensive planning and decision making to more participatory, ecosystem/integrity-based, adaptive planning, although most analysts agree that the transformation is not complete.

By the late 1980s, many of the "old dogs" were retiring and were replaced by a new generation of natural resources managers, many fresh out of progressive academic programs. They began to transform the agencies. In professional forestry associations and in the Forest Service, for example, a new movement called New Perspectives, then New Forestry, began to rethink forest management in response to concerns over diminishing public support, declining biodiversity, and long-term ecosystem health that would ultimately determine resource sustainability. By the early 1990s, this movement evolved to EM, which Forest Service chief Dale Robertson declared in 1992 would be the policy for the national forest system.

However, efforts to institutionalize this policy in Forest Service planning regulations in 1995 met with political opposition from commodities interests who feared diminished production from the national forests and from some policy analysts who questioned the ability to systematically manage the resources on an ecological rather than an economic basis (Flick and King, 1995). The proposed rules were withdrawn, and attention was refocused on "forest health" (a "Mom and apple pie" issue no one could oppose) rather than EM. By late 2000, however, the National Forest Service did approve revised planning rules, incorporating many of the principles of EM, as shown in box 10.1 (USDA, USFS, 2000). But the Forest Service had been practicing EM for many years under the 1992 administrative policy, and forest management plans began reflecting the principles long before the change in rules (Phillips and Randolph, 1998). Some of these cases are presented in the last section of this chapter.

Ecosystem Management on Private Lands

Many skeptics thought that EM would be limited to public land and resource applications because of the complexities involved. They assumed that single ownership of large blocks of natural landscapes was necessary to achieve ecosystem functions and objectives. However, in April 1993 Secretary of Interior Bruce Babbitt described three habitat conservation plans (HCPs) on private land under the Endangered Species Act (ESA) as examples of "ecosystem management." Responding studies of HCP projects conducted at that time showed that they fell short of the EM criteria given in the "Ecosystem Management Criteria" list (Smith 1995). Still, his statement begged the question of whether or not EM could be practiced on private lands.

Land conservation efforts across the country during the 1990s indicated that EM principles could be used in managing ecosystem integrity and biodiversity at a variety of scales and ownerships by federal, state, and local agencies; property owners; and nonprofit groups. These efforts are chronicled in different sources, including Yaffe et al.'s (1996) "Ecosystem Management in the United States: An Assessment of Current Experience." These inventories list hundreds of examples of mostly community-based activities in ecological restoration, landowner stewardship, land trusts for habitats and biodiversity, and other programs and projects. Although these projects are labeled "ecosystem management," most of them used watersheds as the defining boundaries for planning and management. With private lands, it is often difficult to distinguish between EM and WSM, especially when watershed protection and restoration programs aim to protect habitats and other ecological resources.

BOX 10.1—Forest Service Planning Rules Reflecting Ecosystem Management Principles

Framework for Planning

1. Identification and consideration of issues
2. Information development and interpretation
3. Proposed actions (plus NEPA requirements)
4. Plan decisions, amendments, revisions
5. Site specific decisions
6. Monitoring and evaluation for adaptive management

Key Principles

- Collaborative planning for sustainability
- Ecological, social and economic sustainability
- Contribution of Science
- Special considerations
- Planning documentation

(National Forest System Land Resource Management Planning: Final Rule, November 2000)

Ecosystem Management, TNC-Style: "Conservation by Design"

Among the groups and agencies throughout the world engaged in some version of EM, The Nature Conservancy (TNC) is a good example. TNC is now the world's largest environmental organization with over 1 million members. As a land trust, the Conservancy has protected 12 million acres in the United States and 92 million acres around the world. As TNC has grown, its mission has become more ambitious. Once focused on protecting unique sites ("the Last Great Places"), the Conservancy now sees a larger potential to piece those places together to preserve "the diversity of life on Earth by protecting the lands and waters" natural communities need to survive. Under its "conservation by design" policy, it aims to conserve "portfolios of functional conservation areas" within and across ecoregions (TNC, 2001).

TNC's approach to "ecoregional planning and management" is characterized as comprehensive, scientific, collaborative, and community-based. TNC has realized that to protect functioning ecosystems, it must look scientifically beyond individual properties to larger ecological mosaics. The following four basic steps, given along with key terms, are used in the conservation-by-design ecoregional planning process:

1. ***Set priorities through ecoregional planning.*** The Conservancy is using the best available science to analyze each of the country's 63 ecoregions, rate the most significant natural areas, and identify the suite of sites (portfolio) that must be conserved within each ecoregion to sustain its ecological processes and diversity.

- **Ecoregion:** Relatively large geographic areas of land and water delineated by climate, vegetation, geology, and other patterns (see figure 10.2).
- **Portfolio:** The suite of conservation areas within an ecoregion selected to represent and conserve the conservation targets and their genetic and ecological variation.

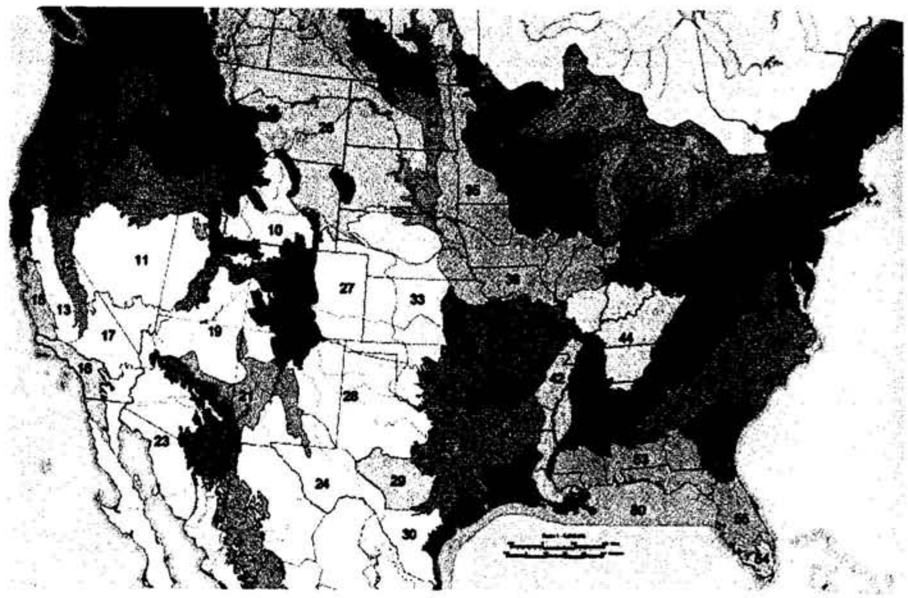


Figure 10.2 63 Ecoregions of the United States. *Source:* Dan Dorfman, The Nature Conservancy, (2001). Used with permission.

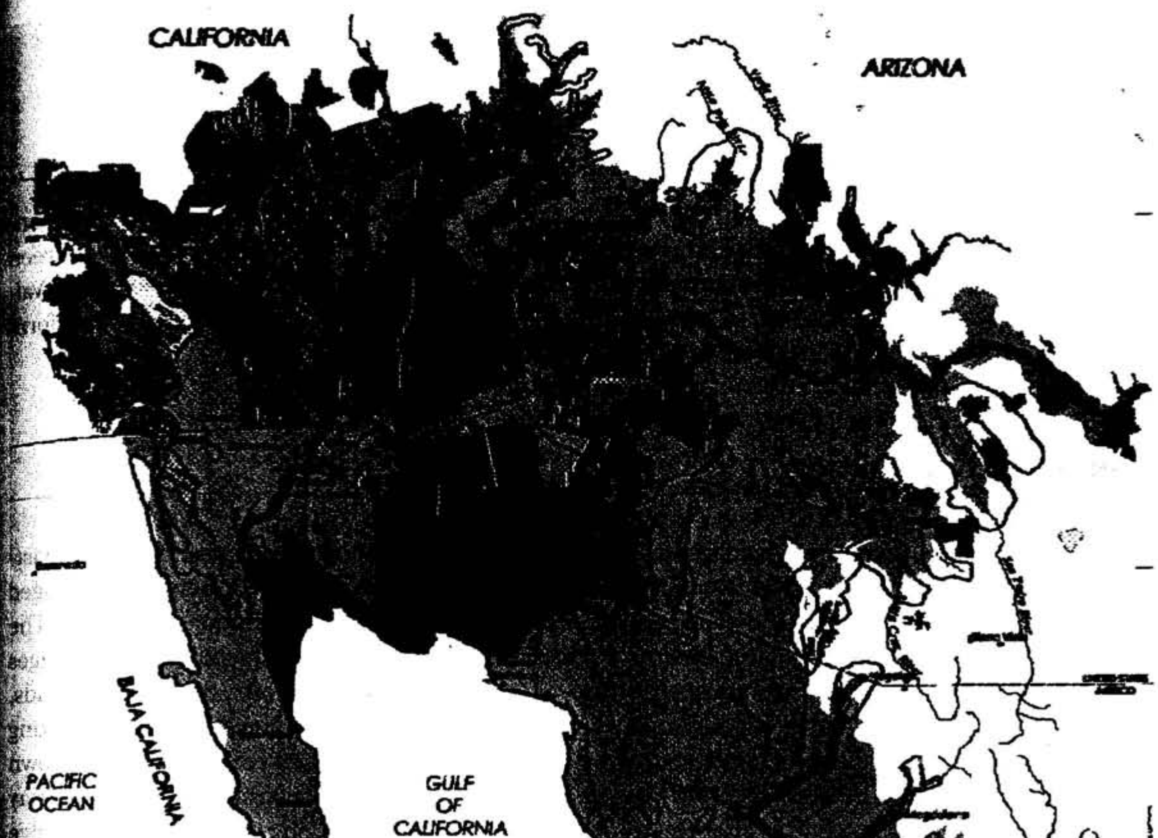
- **Conservation targets:** Specific components of biodiversity used to design ecoregional portfolios and develop and prioritize conservation strategies: ecological systems, natural communities, species (see figure 10.3 of Sonora Desert).

2. ***Develop conservation strategies.*** Identify conservation targets and evaluate methods of abating threats by analyzing stresses (e.g., inappropriate development, ditching/draining wetlands, fire suppression, habitat fragmentation, degradation of waterways, invasive species).

- **Platform sites:** Placed to showcase effective threat abatement and ecosystem protection by collaborating with key agencies, organizations, and individuals whose partnerships are essential to achieve tangible, lasting conservation at an effective scale.
- **Functional landscapes:** Intended to conserve all biodiversity and are large in scale (>20,000 acres).

3. ***Take direct conservation action.*** TNC often tries to identify unroaded natural areas that may serve as functional landscapes that may be available for protection. Figure 11.20 shows a GIS inventory map produced from data layers on vegetation and roads that shows such forested blocks >15,000 acres. TNC can then target these areas for acquisition or conservation easements.

- **Conserve:** Area is conserved or functional when its biodiversity health score has achieved a rank of good or very good, and its threat is low or medium.
- **Functional conservation area:** Geographic area needed to maintain conservation targets and supporting ecological processes within acceptable ranges of variability over the long term.



1 An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a natural state within which disturbance events (of natural type, frequency, intensity, and legacy) are allowed to proceed without interference or are mimicked through management.

1.3 Million Acres within Ecoregion **1.3 Million Acres within Conservation Sites**

2 An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a primarily natural state, but which may receive uses or management practices that degrade the quality of existing natural communities, including suppression of natural disturbance.

4.8 Million Acres within Ecoregion **3.2 Million Acres within Conservation Sites**

3 An area having permanent protection from conversion of natural land cover for the majority of the area, but subject to extractive uses of either a broad, low-intensity type (e.g., logging) or localized intense type (e.g., mining). It also confers protection to federally listed endangered and threatened species throughout the area.

12.1 Million Acres within Ecoregion **5.9 Million Acres within Conservation Sites**

4 There are no known public or private institutional mandates or legally recognized easements or deed restrictions held by the managing entity to prevent conversion of natural habitat types to anthropogenic habitat types. The area generally allows conversion to unnatural land cover throughout.

37.0 Million Acres within Ecoregion **12.9 Million Acres within Conservation Sites**

Figure 10.3 GAP Analysis of Sonoran Desert Ecoregion Showing Conservation Sites and GAP Status Codes (1–4). *Source:* Rob Marshall, The Nature Conservancy, 1999. Used with permission.

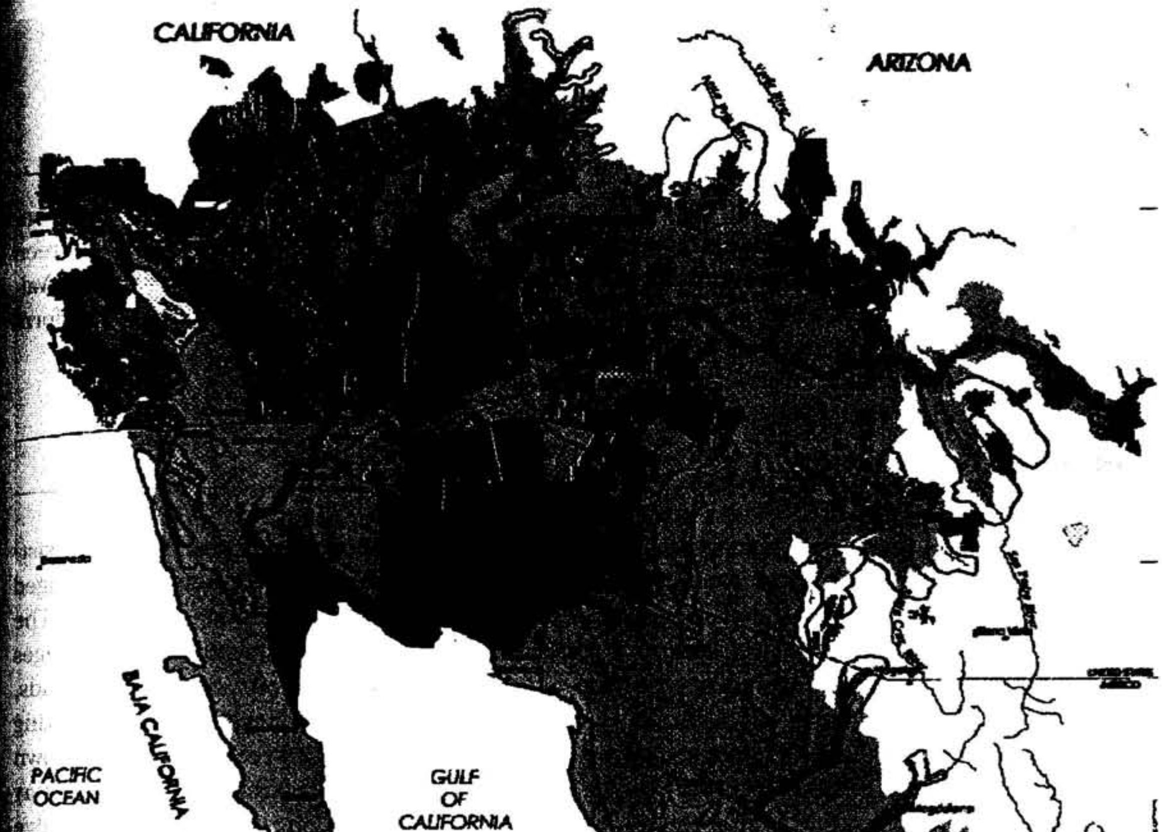


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Figure 10.3 GAP Analysis of Sonoran Desert Ecoregion Showing Conservation Sites and GAP Status Codes (1–4). *Source:* Rob Marshall, The Nature Conservancy, 1999. Used with permission.

- **Functional sites:** Intended to conserve a small set of conservation targets, such as one species with limited spatial requirements.

4. ***Measure conservation success.*** After conservation action is taken, monitor biodiversity and ecological health.

For example, Virginia has six distinct ecoregions and TNC has applied its conservation by design approach in six portfolio areas (Virginia Coast Reserve, Green Sea, Chesapeake Rivers, the Piedmont, Warm Springs Mountain, and Clinch Valley Reserve). In each area, TNC staff work with local communities on platform programs to conserve sites and ecological functions.

Ecological Restoration

Ecosystem management usually focuses on protection and conservation of existing ecological resources. However, in many cases, human impacts have damaged resources and ecological functions to the extent that restoration is required. The growing field of ecological restoration has developed in response to challenges posed by overgrazing, surface-mined land, clear-cut forests, damaged wetlands, contaminated soils, and degraded surface and groundwater. Nature has amazing resiliency and restorative capacity. Left alone, damaged ecosystems have shown an inherent ability to recover. However, recovery takes considerable time and may not occur at all if the threats or causes of degradation are not removed. Active restoration practices can remove threats and accelerate recovery.

Some define ecological restoration as the return of an ecosystem to a close approximation of its condition prior to disturbance (National Research Council [NRC], 1992). However, because of constraints on knowledge of preexisting conditions and costs, this ideal is often impractical. As a result, the Society for Ecological Restoration (SER) provides this definition:

> Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed. It involves restoring and managing ecological integrity, which includes a critical range of variability in biodiversity, ecological processes and structures, regional and historical context, and sustainable cultural practices. (SER, 2002)

Several terms used in the restoration literature have subtle but important differences (SER, 2002):

- **Restoration** aims to reestablish preexisting biotic integrity in terms of species composition and community structure.
- **Rehabilitation** emphasizes reparation of ecosystem processes and services (e.g., reforestation).
- **Reclamation** provides stabilization of terrain, public safety, aesthetic improvement, and return of the land to productive use (e.g., mined land reclamation).

- **Mitigation** lessens or compensates environmental damage (e.g., rehabilitating a wetland to compensate for filling a wetland).
- **Creation** is the establishment of a different kind of ecosystem from what occurred historically (e.g., created wetlands).
- **Ecological or bio-engineering** manipulates natural materials and living organisms to solve problems (e.g., streambank stabilization).

Restoration potential depends on the degree of disturbance of both the site and its surrounding landscape, but the site's condition is more important (NRC, 1992). An important consideration in ecological restoration is the reference ecosystem or conditions that serve as the model for planning and evaluating a project. References are usually given as a composite description of conditions and processes taken from multiple sites.

The SER provides guidelines for developing and managing restoration projects (Clewell, Rieger, and Munro, 2000):

- *Conceptual planning* delineates the site, the type of restoration project, restoration goals, and interventions needed.
- *Preliminary tasks* include organizing and staffing, gathering baseline data, setting objectives, and engaging the public and other stakeholders.
- *Installation planning* provides more detailed plans, performance standards and monitoring procedures, and procurement of materials, prior to the actual *installation actions*.
- *Postinstallation tasks* include site protection, maintenance, monitoring, and adaptive management as recommended by *evaluation*.

Principles and Process of Watershed Protection

Water resources engineers have long recognized the need to manage watersheds to maintain yields and quality of water supply reservoirs. At a larger scale, river basin commissions were established in the 1960s to provide a broader approach to water management. Some of these commissions, like the Delaware River Basin Commission, were successful at improving water conditions, but others became mired in interjurisdictional conflicts across state boundaries.

In the 1990s, the U.S. EPA and other agencies recognized the limitations of point discharge controls and other conventional approaches to water quality and quantity management. It became clear that managing a water body requires managing the land that drains to it. The watershed or drainage catchment became a useful geographic boundary for managing land and water resources. Based on many experimental local programs, the EPA developed guidance for what emerged as the watershed protection approach. Watershed management was not a new concept, but when coupled with new collaborative planning, it has become an effective approach to environmental management.

The Watershed Protection Approach

In 1996, the EPA promoted its watershed protection approach (WPA), which was based on the premise that water quality and ecosystem problems can best be addressed at the watershed level, not at the individual water body or discharge level (U.S. EPA, 1996). There are now an estimated 3,500 active watershed groups in the United States implementing variations of this approach. Many states have adopted WSM as an organizing approach for their water quality management programs. EPA embraced the watershed approach in its Clean Water Action Plan of 1998, but the approach is still not formally part of the Clean Water Act, which has not been reauthorized since 1987. Although it was born in the Clinton administration, the WPA is nonpartisan, as demonstrated in the January 2002 announcement of the George W. Bush administration's initiative for renewed federal support for community-based watershed protection (U.S. EPA, 2002).

The WPA has four basic principles:

1. Targeting priority problems and applying good science to understand them
2. Promoting a high level of collaboration through stakeholder involvement
3. Integrating multiple solutions from multiple agencies and private parties
4. Measuring success through monitoring and other data gathering

The following list outlines three components of a typical WSM program: inventory, planning, and implementation. The inventory is a key first step. Subsequent chapters describe several methods of assessing the watershed and its lands and waters.

Three Components of a Watershed Management Program (*Source:* Commonwealth of Virginia, 1999)

A. Inventory

1. Define the *watershed boundary.*
2. *Identify the stakeholders* responsible for developing, implementing, and updating the plan to ensure long-term accountability. Engage the stakeholders in inventory, planning, and implementation.
3. Conduct a *watershed inventory* of natural resource features (wetlands, floodplains, stream corridors, greenways, rare and endangered species, steep slopes, erodible soils, karst bedrock areas, sensitive habitats, fish and wildlife resources, recreational areas, sources of water supply).
4. Conduct a *stream inventory* (size, order, water and habitat quality, flow regime).
5. Identify significant *environmental features* in neighboring watersheds (large pollution sources, wildlife refuges, sources of water supply).
6. Identify and quantify *existing sources* of point and nonpoint source pollution.

7. Model the *existing hydrology* and hydraulics of the watershed (understand the impact of land use, conveyances, land cover, stormwater management facilities, stream cross sections, roadway crossings, flooding, and drainage problems).

B. Planning
1. *Define the goals* of the WSM plan (what is envisioned for the watershed and who is going to lead the implementation efforts).
2. Identify and quantify *future sources* of point and nonpoint source pollution.
3. Model the *future hydrology* and hydraulics of the watershed.
4. *Develop and evaluate alternatives* to meet the goals and manage water quality (point and nonpoint source pollution) and quantity (hydrology and hydraulics).
5. Identify *opportunities to restore* natural resources.
6. *Develop the WSM plan* (include specific recommendations on development and land use evaluation, selection of structural and nonstructural BMPs, public education needs, regulatory requirements, and funding).

C. Implementation
1. Define the *implementation costs* (capital costs and annual administrative, operations and maintenance costs) and who will pay for the implementation of the WSM plan (provide incentives and secure commitments).
2. Establish an implementation schedule.
3. Develop a watershed monitoring program.
4. Develop an evaluation and revision process for the WSM plan.

EPA uses its watershed protection website (www.epa.gov/owow/watershed/) to network the hundreds of active local watershed management groups throughout the country. The agency continues to provide useful guidance based primarily on local experience (U.S. EPA, 1995, 1997, 2000a, 2000b, 2001).

Other organizations have advanced the cause and practice of watershed protection. The nonprofit Center for Watershed Protection, founded and directed by Tom Schueler in Ellicott City, Maryland, is one of the best sources of practical and technical information on watershed planning and restoration (see www.cwp.org, www.stormwater.org).

Center for Watershed Protection's Basic Concepts in Watershed Planning

The following list shows some basic concepts in watershed planning taken from Schueler (2000). These are based on Tom Schueler's considerable experience including his work at the Metropolitan Washington Council of Governments (e.g., Schueler, 1987), numerous case studies of projects throughout the country, and recent innovative guidance for watershed and stormwater management prepared by the Center for Watershed Protection (Commonwealth of Virginia, 1999; State of New York, 2001) (see chapter 14).

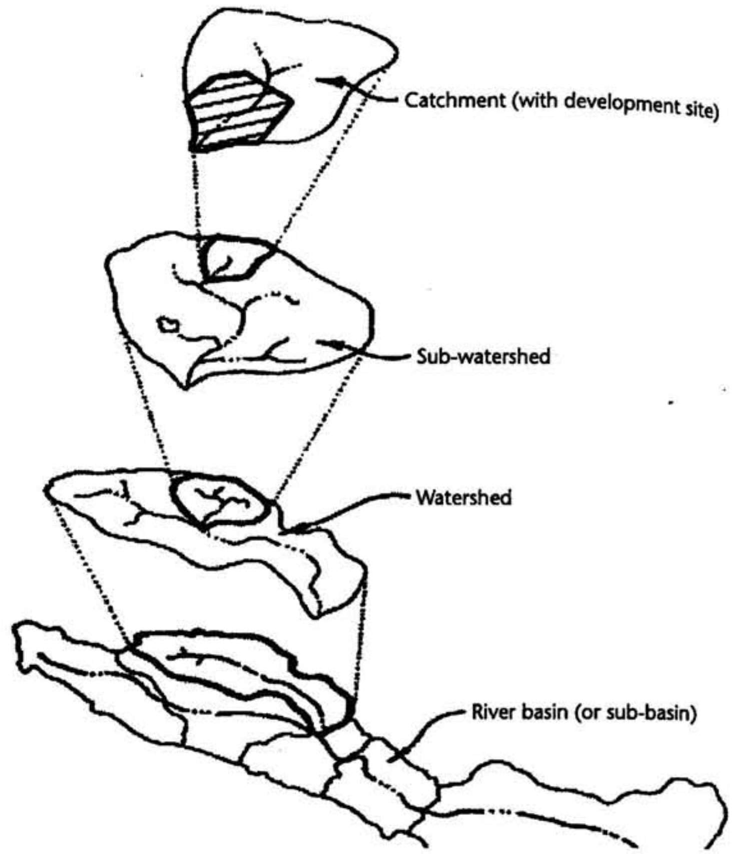

Figure 10.4 Nested Watersheds. *Source:* Adapted from Schueler (2000).

Basic Concepts in Watershed Planning (after Schueler, 1997, 2000)

1. The Tiered Approach: Nest your watersheds—think globally (basin), act locally (catchment).
2. Classify your subwatershed.
3. Take care of precious headwaters.
4. Employ eight WSM tools: land use planning, land conservation, aquatic buffers, cluster and low-impact site design, erosion and sediment control, stormwater treatment, control of septic system and other discharges, and watershed stewardship and monitoring.
5. Focus on impervious cover in urban watersheds.
6. Make technical choices about mapping, modeling, monitoring, and management measures.
7. Reach broad consensus among stakeholders.
8. Focus on action: Implement your watershed plan.

The **tiered approach** or watershed nesting relates to **scale.** Watersheds are defined by a point on a stream or river and include the land area draining to that point. Chapter 13 describes a method to delineate watersheds. Watershed size can range from very large basins to very small catchments (see figure 10.4). Table 10.1 describes the characteristics of each. As you move from larger basins to smaller catchments, the effect of impervious cover on watershed health increases and management measures converge from basinwide planning to on-site design and management practices.

- Catchment: area that drains development sites to their first intersection with stream
- Subwatershed: 1–10 square miles: second-order streams
- Watershed: 10–100 square miles
- Subbasin: 100–1000 square miles
- Basin: 1000–10,000 square miles

Watershed units in the United States are defined by **hydrologic unit code** (HUC) using a system developed by USGS. The hierarchy is described in table 10.2, which shows an example from South Carolina. HUCs are based on a classification system that divides the United States into progressively smaller hydrologic units. Each unit is identified by a unique HUC consisting of two to eight digits based on the four classification levels. NRCS and other agencies have further delineated fifth- and sixth-level watersheds in many states. HUCs for these additional watershed levels consist of 11 and 14 digits, respectively, and represent a scale from a few hundred down to tens of square miles. Fifth- and sixth-level HUCs are generally a good scale for watershed projects (U.S. EPA, 2000a).

TABLE 10.1 Characteristics of Five Watershed Management Units

Watershed Management Unit	*Typical Area (square miles)*	*Influence of Impervious Cover*	*Sample Management*
Catchment	0.05 to 0.50	Very strong	Practices and site design
Subwatershed	1 to 10	Strong	Stream classification and management
Watershed	10 to 100	Moderate	Watershed-based zoning
Subbasin	100 to 1,000	Weak	Basin planning
Basin	1,000 to 10,000	Very weak	Basin planning

TABLE 10.2 Example of Hydrologic Unit Codes (HUCs) from South Carolina

HU Level	*Hydrologic Unit*	*Hydrologic Unit Name*	*Hydrologic Unit Area (mi²)*	*HUC*
1st	Region	South Atlantic Gulf	—	03
2nd	Subregion	Edisto-Santee	23,600	0305
3rd	Basin (Accounting Unit)	Santee	15,300	030501
4th	Subbasin (Cataloging Unit)	Enoree	731	03050108
5th	Watershed	Unnamed	82	03050108040
6th	Subwatershed	Unnamed	41	03050108040010

Source: Bower, Lowery, Lowery, and Hurley, 1999.

Most effective watershed planning is guided by larger issues of the basin but focuses on smaller scale subwatersheds and catchments for action. Guidance, policies, and financial and technical assistance may be basinwide, but specific plans and implementation occur in subwatersheds. The **subwatershed** is a critical scale for management: It is small enough to be within one or a few jurisdictions, there is a strong influence of land use and impervious surface, there are few compounding pollutant sources, it is small enough for monitoring and mapping at a workable yet detailed scale, and stakeholders have a close connection to the issues and are manageable in number.

Watershed classification helps focus on planning objectives. Table 10.3 gives eight categories of subwatersheds based on their condition, location, and beneficial use. "Sensitive," "impacted," and "nonsupporting" categories reflect the degree of impairment depending on habitat and water quality. "Restorable" are those impacted or nonsupporting streams that have a high potential for restoration. "Urban lakes" and "coastal-estuarine waters" indicate location and sensitivity. "Water supply reservoir" and "aquifer protection" trigger a public health objective.

Watershed and Ecosystem Assessment

Scientific and technical assessment plays a critical role in EM and WSM. Scientific inventory and analysis are used to evaluate ecosystem/watershed conditions and problems, guide the choice of protection and restoration measures, and monitor progress in adaptive management.

Assessment in EM depends on management objectives and can be complex. In recent years, we have gained considerable knowledge about ecosystem functions and dynamics from conservation biology and landscape ecology. We continue to improve our understanding of natural systems. However, we often need to make decisions about resources without perfect knowledge of the systems involved. The goal of adaptive management is to learn from these decisions by taking limited action and monitoring results. In most cases this is an appropriate means of managing resources and adding to our understanding of ecosystems. But in some cases it is a risky business if the action taken causes irreversible change to sensitive or endangered species before we have a chance to monitor the effects.

Watershed assessment is normally more straightforward. The hydrologic and water quality systems are more predictable than ecological systems. However, ecological components of watershed assessment often encounter the same uncertainties as ecosystem assessment. Watershed assessment usually focuses on the stream channel, the riparian zone, and upland areas. In urban watersheds, special attention is given to impervious surface relationships and effects.

Assessments should make good use of visual and mapping tools. Maps can show subwatershed and catchment boundaries; land use and land cover; ecosystem and watershed resources and conditions; and location of floodplains, stream buffers, wetlands, land conservation areas, stormwater practices, strategic monitoring stations, and many other features. Geographic information systems (GIS) can inte-

TABLE 10.3 **Categories of Subwatersheds**

Subwatershed Category	*Description*
Sensitive Stream	Less than 10% impervious cover High habitat/water quality rating
Impacted Stream	10% to 25% impervious cover Some decline in habitat and water quality
Nonsupporting Stream	Watershed has greater than 25% impervious cover Not a candidate for stream restoration
Restorable Stream	Classified as Impacted or nonsupporting High retrofit or stream restoration potential
Urban Lake	Subwatershed drains to a lake that is subject to degradation
Water Supply Reservoir	Reservoir managed to protect drinking water supply
Coastal/Estuarine Waters	Subwatershed drains to an estuary or near-shore ocean
Aquifer Protection	Surface water has a strong interaction with groundwater Groundwater is a primary source of potable water

Source: Schueler (2000).

grate existing maps and digital data, as well as remote sensing information like aerial photos and digital images, into assessment product maps (see chapter 11).

The rapid-intermediate-advanced assessment approach is often applied to watershed and ecosystem studies. Rapid assessment relies primarily on existing information such as natural resource maps and past environmental reports. Although it is somewhat broad-based and qualitative, rapid assessment can reveal important insights about watershed functions and interactions. Some limited action may be taken based on the results of rapid assessment.

In intermediate and advanced assessment, experienced analysts utilize more data collection, quantitative assessment tools, field surveys, and computer-based models to provide a higher level of certainty or confidence in the assessment results. This requires more time and resources than rapid assessment but is often necessary when rapid results are indeterminate.

Subsequent chapters present a wide range of methods that are used in watershed and ecosystem assessment. Rapid assessment relies primarily on existing information, much of which is available in local agency offices and on the Internet. EPA's EnviroMapper Storefront (http://www.epa.gov/enviro/enviromapper) and Fish and Wildlife Service's Interactive wetland mapping tool (http://wetlands.fws.gove/mapper_tool.htm) are especially useful. For rapid watershed assessment, a first step is EPA's Surf Your Watershed site (http://www.epa.gov/surf), which allows selection of watersheds down to HUC level 4 (subbasin). A wide range of information is available for these watersheds, including location of impaired waters from EPA's database, locations of toxic releases and superfund sites, and registered stream restoration efforts. The interactive site allows users to add information to the database. There is a link to EPA's Index of Watershed Indicators, which gives a wide array of water quality, ecological, and demographic data for the subbasin. Box 10.2 lists those indicators and also provides links to the EPA's website describing them.

BOX 10.2 Index of Watershed Indicators (IWI) Developed by the EPA

1. Population Served By Community Drinking Water Systems Violating Health-Based Requirements (01)
2. Population Served By Unfiltered Surface Water Systems at Risk from Microbiological Contamination (02)
3. Population Served By Community Drinking Water Systems Exceeding Lead Action Levels (03)
4. Source Water Protection (04)
5. Fish Consumption Advisories (05)
6. Shellfish Growing Water Classification (06)
7. Biological Integrity (07)
8. Species at Risk (08)
9. Wetland Acreage (09)
10. Drinking Water Supply (10a)
11. Fish and Shellfish Consumption (10b)
12. Recreation (10c)
13. Aquatic Life Designated Use (10d)
14. Ground Water Pollutants: Nitrate (11)
15. Surface Water Pollutants (12)
16. Selected Coastal Surface Water Pollutants in Shellfish (13)
17. Estuarine Eutrophication Conditions (14)
18. Contaminated Sediments (15)
19. Selected Point Source Loadings to Surface Water (16a)
20. Sources of Point Source Loadings Through Class V Wells to Ground Water (16b)
21. Nonpoint Source Sediment Loadings from Cropland (4)
22. Marine Debris (18)

Note: Each line above has a link to an Internet description of each indicator. For first indicator go to www.epa.gov/iwi/help/indic/fs1.html; replace "1" in URL with number given in parentheses above for other indicators.

Integrating Compatible Programs and Solutions

There is no "silver bullet" for protecting and restoring ecosystems and watersheds. A wide range of measures must be used to preserve existing values and improve degraded conditions. Watershed and ecosystem management measures include regulations, restoration projects, land acquisition, environmental monitoring, stewardship by land trusts and landowners, and education and research. Regulations on land use, polluting actions, and ecosystem-impacting practices take the form of permitting programs requiring compliance with rules or ordinances designed to protect lands, waters, and habitats. Although these regulations provide an important foundation for protective action, they are insufficient to achieve effective management. They may help to prevent further degradation, but improvement and restoration of watersheds and ecosystems often requires proactive measures to acquire, restore, steward, and monitor natural resources.

To accomplish this comprehensive array of measures, holistic ecosystem and watershed management must team with other programs with common and compatible objectives. Perhaps not surprisingly, a range of programs designed to provide economic and social benefits can also protect and enhance watersheds and ecosystems. These include programs to mitigate natural hazards, arrest soil erosion, preserve farmland, treat polluted runoff, protect drinking water sources, restore impaired/TMDL waters, manage forests, improve air quality, protect wetland benefits, manage fisheries, provide recreation and open space, and enhance the quality of life in our communities.

Watershed and ecosystem management add ecological dimensions to these human-related objectives, but most are very compatible. Successful programs take advantage of the synergies provided by coordination and collaboration of diverse initiatives. Such programs enjoy a broader base of support, greater acceptability, improved cost-effectiveness, and smoother implementation.

Achieving this collaboration is easier said than done. Public interests, groups, and agencies are often fragmented in their objectives and programs. Competition for scarce resources (time, money, institutional capacity) often pits one against the other. Successful programs have realized the advantages of building partnerships and pooling social, political, and financial capital into comprehensive efforts of common interest. Often this begins with appropriate institutional arrangements.

Institutional Arrangements for Ecosystem and Watershed Management

Ecosystem and watershed protection requires an integration of science, planning, policy, and politics. The nested or tiered approach (figure 10.1) applies not only to scientific understanding, but also to institutional and political organization. As we move from catchment to watershed to basin and from patch to matrix to ecosystem, the increasing geographic area captured crosses governmental jurisdictional boundaries. As we increase the number of jurisdictions, we complicate the institutional and political arrangements needed for effective management. Since watersheds and ecosystems rarely conform to jurisdictional boundaries, WSM usually requires interjurisdictional collaboration. However, parochial interests, competition, and past conflicts often inhibit meaningful cooperation among neighboring jurisdictions.

In addition, WSM also must involve private landowners and the public, as well as governmental agencies in a collaborative partnership. Although some regulatory land use controls are important, effective watershed protection depends on a range of voluntary measures, including land stewardship and watershed monitoring. Watershed associations and groups are critical players in WSM.

These institutional issues are well recognized by research on the practice of ecosystem and watershed management (Schueler, 2000; U.S. EPA, 1997). From 1999 to 2001, an interagency federal watershed protection team worked with local and state partners and watershed practitioners to assess the challenges to watershed health, recent successes of the watershed approach, and remaining obstacles. The process engaged more than 1,000 participants at 20 regional roundtable discussions, culminating in the National Watershed Forum in the summer of 2001 (Meridian Institute, 2001a, 2001b; U.S. EPA, 2001).

The roundtables and Forum concluded that the watershed approach offers the best hope for protecting and restoring the nation's waters. They gave much of the credit for successes to date to *local leadership and engagement.* "Citizens are leading the drive to reverse impacts to watershed health" (U.S. EPA, 2001).

The Forum also cited the importance of federal and state agencies for coordinating and supporting local watershed protection with financial and technical

TABLE 10.4 **Institutional Arrangements at Different Watershed Scales**

Scale	*Participants*	*Roles and Actions*	*Examples*
Region (subnational)	• Lead federal agency • Multiagency committee	• Federal commitment to watershed approach • Interagency agreements • Funding, technical support	• Federal unified policy • Regional teams
Basin (multistate)	• Lead federal agency • Multistate advisory group with federal and state reps, interest-group reps • Committees, task forces, stakeholders groups	• Multistate commitment • Basin plan • State/federal financial support	• River basin commissions • Great Lakes Joint Comm. • Chesapeake Bay program
Subbasin (state)	• Lead state agency • Statewide advisory committee with state and regional and interest group representatives • Committees, task forces, stakeholders groups	• State statutory/administrative directive for WSM • Statewide watershed protection plan • Requires regulatory "teeth" • Technical and financial assistance to watershed/ subwatershed programs	• Oregon Plan for Salmon and Watersheds • Illinois River • Chesapeake Bay acts in Maryland and Virginia
Watershed (substate)	• Regional planning agency (e.g., COG, plan. district) • WS advisory committee of local governments, regional groups, other stakeholders	• Interjurisdictional plans and agreements • Guidance, technical and financial support	• Cuyahoga River, OH • San Miguel River. CO
Subwatershed (local)	• Watershed association (local government, landowners, interest groups) • Local watershed manager/ coordinator	• Where the action is! • Land use controls • Stream/riparian restoration • Action limited without direction, financial, technical support from above	• Anacostia Watershed, DC • Matapole River, CA • East Fork of Little River, VA • Bronx River, NY
Catchment (site scale)	• Watershed association, Watershed coordinator • Landowners, developers, community groups	• Site development measures • Land stewardship • Stream/riparian restoration • Stream monitoring	• Haskell Slough, WA

support. Specifically, the Forum provided a range of recommendations, dealing largely with institutional issues of education, partnerships, planning, funding assistance, and implementation. Although scientific and technical factors are critically important in watershed and ecosystem management, these institutional issues continue to be the major challenges to effective protection and restoration.

Institutional Models for Watershed Management

Several organizational models for WSM and EM have emerged, but most involve a tiered approach and public-private-nonprofit partnerships. Although most management actions occur at the local level, larger-scale watershed and ecosystem institutional frameworks provide guidance and resources to smaller-scale planning and implementation efforts. Table 10.4 outlines participants and organizational units, roles and actions, and examples of WSM programs at various scales from subnational regions to site-level catchments.

Actions and measures are implemented at the subwatershed and catchment scale, but studies have shown that these programs often have limited effectiveness without technical and financial support from the regional subwatershed or state levels (Holst, 1999).

Research on local environmental planning has shown that key ingredients for successful community initiatives are a *committed elected official* who can advance the cause politically, a *skillful planner* who can generate and manage technical information, and an *active constituency* that contributes political support and local knowledge (Corbett and Hayden, 1981). This holds true for WSM as well. Support of elected officials is important to shepherd watershed protection regulations and funding. The "planner" is often played by the watershed manager. The constituency can be represented by the watershed association or stakeholders group, which not only provides political support but also monitors watershed conditions and implements restoration measures through voluntary action.

The Watershed Group/Association

A local watershed association often plays an important role for subwatershed and catchment planning and implementation. The association is usually composed principally of landowners in the subwatershed, but may also include government officials and interest groups. With landowner participation, the association can be instrumental in developing stewardship, monitoring, and other voluntary measures. In some cases, the group has legal authority, in some cases not. In either case, the association is well positioned to understand local problems and issues, to develop options to address them, and to implement these measures. At the subwatershed level, associations provide a mechanism for local governments and interest groups to gather watershed stakeholders to plan and implement protection and restoration. In the cases described in box 10.3 later in this chapter, the Bronx River Working Group and the Cuyahoga River Alliance are good examples of watershed associations.

Some associations have legal standing. For example, Virginia law allows the establishment of a watershed improvement district (WID) if voters and landowners approve such a district by large majorities. The WID is made up of landowners and has the authority to tax its members to fund watershed improvements. The Barcroft Reservoir WID in urban Fairfax County was established under this law in the 1970s. The district has developed a tax-supported fund to pay for monitoring and BMP retrofits. While the district has maintained the lake, its capacity to improve the watershed has been limited to lakeshore and tributary activities rather than upstream measures in the heavily urbanized watershed.

Most associations are voluntary groups. The East Fork (Little River) Watershed Association in Floyd County, Virginia, was established by local landowners with the help of the National Committee for the New River (NCNR) in the early 1990s. The agricultural watershed is made up of fiercely independent landowners—some long-term natives known for their taste for moonshine and some "urban refugees" who migrated from the northeast to enjoy a more communal life. While these groups are culturally very different, they both are distrustful of government, guard their property rights, and take pride in the fact that all water flows out of Floyd County. The perceived threat of government action on their impaired watershed drew these diverse landowners together in a common cause. NCNR helped educate this group about the watershed's problems and convinced them that they should take action themselves before state agencies came in and told them what to do. This argument struck a chord, and the group succeeded in developing a plan, acquiring grant funds, monitoring watershed quality, and implementing livestock fencing and other measures to reduce runoff pollution.

The Watershed Manager

The watershed manager is usually a paid staffer of local government or a large watershed association who plays a lead role in planning and coordinating watershed information, process, decisions, and implementation. The manager is usually the keeper of information on watershed data and analysis and on potential protection and restoration measures and costs. The manager will often coordinate the collaborative process, identifying stakeholders, setting up advisory committees, and organizing meetings.

Stakeholder Involvement and Advisory Committees

Stakeholder involvement is a critical part of watershed and ecosystem management. As discussed in chapter 4, stakeholders are those who effect change in the watershed and those who are affected by it. They include agencies, local governments, landowners and developers, and environmental, agricultural, and other interest groups. Stakeholder groups are used at all levels of watershed management, from basin to watershed to catchment scale.

Several approaches to stakeholder involvement were discussed in chapter 4. Stakeholder groups are organized as information task forces, working groups, or advisory committees. Representation on stakeholder groups varies with scale. At the basin level, committees are made up of representatives of federal and state agencies and national interests groups. At the watershed scale, stakeholder groups include state agency officials, local governments, and state or regional interest groups. At the subwatershed level, groups may be the same as watershed associations, including landowners and community groups.

Bauer (2001) and Keuhl (2001) each studied the collaborative process of stakeholder groups. Bauer showed that community-scale watershed groups are potentially more effective in learning and reaching consensus than basin-scale groups because they are closer to the problems and potential solutions. Keuhl (2001) investigated advisory committees in the Great Lakes Remedial Action Planning and found that the collaborative process led not only to consensus-building, but also to increased knowledge of water and watershed systems and improved understanding of problems and solutions.

Integrating Statewide and Local Watershed Programs

The plethora of case studies of the practice of WSM and EM has demonstrated the importance of local action (U.S. EPA, 2001; Williams, Wood, and Dombeck, 1997).

However, successful local programs rarely act alone. They often depend on administrative or statutory direction from above, guidance from basin and watershed plans produced at the state or regional level, technical assistance, and especially financial support from state and federal agencies. Likewise, statewide, basin, and watershed-level programs require not only local action but also consistent reporting and monitoring of local restoration and protection projects.

A good example of integrating statewide and local programs is Oregon's framework. The state-level *Oregon Plan for Salmon and Watersheds,* funding from the Oregon Watershed Enhancement Board, watershed level programs like the Willamette Restoration Initiative, and the 90 subwatershed councils around the state provide the institutional structure. The Watershed Restoration Reporting system provides consistent and timely feedback on local activities to the state so that progress can be effectively monitored. The Oregon framework is described in the next section.

Other states, like Wisconsin, Minnesota, North Carolina, and Maryland, among others, have integrated the WPA into their water quality programs. All of these states provide technical and funding support for local subwatershed planning and implementation. These programs often build on established state programs and agencies, such as soil and water conservation districts in rural areas. However, local watershed groups are critical, especially in urban and suburban areas.

Applications of Ecosystem and Watershed Management

Thousands of experiments in watershed and ecosystem management have been developed over the past decade (Bauer and Randolph, 2000; U.S. EPA, 1997, 2000b, 2002; Yaffee et al., 1996). Because they are experimental, there is a strong need to monitor and evaluate experiences to see what works and what doesn't. This section reviews some of these experiences. After a look at EM in the Forest Service, it reviews a few examples of community-based watershed management that show success depends on technical expertise, hard work, and elements of a social movement. The section concludes with a review of Oregon's Plan for Salmon and Watersheds, among the more comprehensive ecosystem/watershed management efforts.

Federal Agency Ecosystem Management

The first section of this chapter described the evolution within federal land agencies toward an EM approach. The Forest Service, the Park Service, the Bureau of Land Management, and the Fish and Wildlife Service have all modified their planning and management of public lands to incorporate emerging methods. This began with sustained yield and multiple use in the 1960s, NEPA requirements and environmental impact assessment in the 1970s, management planning in the 1980s, and more collaborative and ecosystem management in the 1990s (Phillips and Randolph, 1998; Randolph, 1987).

In the summer of 1992, Forest Service chief Dale Robertson announced the agency's intent to develop EM as "a strategic approach for sustaining desired conditions of ecosystem diversity, productivity, and resilience for the multiple uses and values of the national forests" (USDA, USFS, 1992; Salwasser, 1994). Although the Forest Service did not modify its planning and management regulations to reflect EM principles until 2000 (USDA, USFS, 2000), the agency began implementing EM principles in 1992.

Phillips and Randolph (1998) reviewed Forest Service plans produced in the mid-1990s in comparison to plans for the same units in the 1980s to assess the extent to which their plans and practices reflected EM principles. For this research, they developed 11 evaluation questions based on an extensive review of the growing ecosystem literature. They involved native species populations, ecological processes, ecosystem health and diversity, different spatial and temporal scales, ecosystem boundaries, collaborative decision making, scientific research, adaptive management, education, and evaluation.

Based on these questions, they conducted content analysis on mid-1980s and mid-1990s plans for George Washington, Francis Marion, and Texas National Forests. In all three cases, the mid-1990s plans addressed the EM criteria to a far greater extent than the mid-1980s plans.

For example, the 1993 George Washington National Forest Plan was developed after the 1986 plan was mired in conflict.

- The 1993 Plan was produced after a two-year collaborative planning process of diverse stakeholders (see chapter 4).
- It called for a 42 percent reduction in area suitable for timber sales, and clear-cutting was reduced by 62 percent compared with the 1986 Plan (close to the Forest Service's EM goal calling for a systemwide clear-cutting reduction of 70%).
- Conversion from native hardwood to non-native softwood species was no longer deemed appropriate.
- Riparian area practices called for "ecologically based width" buffers rather than no or standard width buffers in the 1986 Plan.
- Lands designated for old-growth conditions and unfragmented habitat increased by 19 percent and 13 percent, respectively, over the 1986 Plan.
- The 1993 Plan maintained 90 percent of the forest in "natural state" under visual quality objectives compared with just 38 percent in the 1986 Plan.

The study concluded that the mid-1990s plans demonstrated a marked change in the use of EM principles. In addition, the 1990s plans were all less controversial and enjoyed much smoother adoption than their 1980s counterparts. A related study also showed that by incorporating EM principles, these plans reflected the goals and objectives of NEPA to a greater extent than did the previous plans (Phillips and Randolph, 2000).

Watershed Success Stories

A number of collections of case studies are helpful guides to watershed management experience. Yaffee et al. (1996), Williams et al. (1997), Schueler and Holland (2000), and the U.S. EPA (1997, 2000b, 2001) chronicle community-based protection and restoration projects across the country. Box 10.3 gives four examples of the 30 watershed success stories presented in the EPA (2000b). The cases are from across the country and range from urban to rural applications. The common threads include local volunteerism and advocacy, planning and assessment, and government support.

Oregon Plan for Salmon and Watersheds

Perhaps one of the best examples of integrated WSM comes from Oregon. Faced with growing concerns over endangered salmon, the Pacific Northwest has tried to manage water and salmon while maintaining economic vitality. Twelve salmonoid species in Oregon have been listed under the federal ESA. In response, Oregon developed a comprehensive approach to restore the salmon species by restoring watersheds. The *Oregon Plan for Salmon and Watersheds* (OPSW) was developed in the mid-1990s and approved by the state legislature in 1997. In 1999, the governor expanded the scope of the plan to watershed health statewide.

The OPSW has been more than a technical exercise to improve watersheds and recover salmon habitat and species numbers; it has become a high-stakes social movement:

> There is a lot at stake. More than just the future of salmon. The nature of Oregon is at stake. Our environment—from the salmon in the streams to the employment opportunities our children will have—depends on the many decisions we make today.... Our task is to conduct our human business in Oregon, in a manner that is compatible with sustaining productive soils, clean drinking water, recreation, cultural values, *and* native salmon populations. (OPSW, 2001)

The inclusive tone of the movement is set in the following quote from the 2001 status report on the Plan.

> **Who Is Responsible for Healthy Watersheds?**
>
> In a world where people often look for simple solutions to complex problems, some people suggest that saving salmon is the responsibility of loggers, or farmers, or fishers, or the tribes, or the people who operate the dams, or the people who build houses, or the people who protect seals, and so-on, and so-forth. That suggestion is *wrong*. Saving salmon—restoring healthy watersheds—will require willing participation of all of us, neighbors in the greater Oregon watershed. Saving salmon must not be viewed as someone else's responsibility—but as *my* responsibility. The reality is that many Oregonians *are* actively involved in the effort to sustain healthy watersheds, clean water, and native fish. (OPSW, 2001)

BOX 10.3—Four Watershed Management Success Stories (U.S. EPA, 2000b)

Bronx River, New York—*Community Cooperation in Urban Watershed Restoration*

The 56.4-square-mile Bronx River Watershed forms New York City's truly urban Bronx River that flows for 23 miles through the New York Botanical Garden, the Bronx Zoo, Soundview, Hunts Point, and other communities before emptying into the Long Island Sound. In the early 1800s, the Bronx River watershed had a magnificent oak forest and abundant wildlife, including beaver and trout. After nearly two centuries of degradation, the Bronx River Working Group was formed in 1997 to coordinate watershed restoration, education, and outreach efforts.

Supported by an EPA Wetlands Protection grant and other sources, the continuously expanding alliance of over 50 community groups, nonprofits, and businesses and government agencies is accomplishing significant watershed restoration and protection. It is acquiring land, restoring river channel hydraulics, stabilizing eroding riverbank with native vegetation, reclaiming wetlands and floodplains, improving habitat, and increasing public access to the river.

Many actions are underway, including a mile-long greenway project in the Soundview section of the watershed. A City of New York Department of Parks and Recreation initiative, the Adopt-The-River Program provides technical and financial assistance to community-based projects. In the fall of 1999 alone, 15 program community events focused on reopening riverside trails, removing debris from the river, restoring wildlife habitat, and developing waterfront access.

Conasauga River, Georgia and Tennessee—*Protecting Wildlife Habitat from Nonpoint Source Pollution*

The 91-mile Conasauga River is home to a remarkable diversity of species, including 25 that are considered rare. In 1999, the USDA Forest Service selected the watershed as one of 12 priority large watersheds, and the river has been identified as one of the most biologically important rivers in the southeast United States. The watershed is impacted by urban, forestry, and agricultural activities. Eighteen miles of the Conasauga River and 54 miles of tributaries are still in Georgia's List of Impaired Waters for fecal, metal, toxic chemical, sediment, and nutrient impacts. The Conasauga River watershed is classified as a Category 1 priority watershed in the state's Unified Watershed Assessment.

In 1994, the Limestone Valley Resource Conservation and Development Council undertook an ecosystem-based study and organized meetings of local stakeholders. Three years later, the council founded the Conasauga River Alliance, a partnership made up of local citizens, conservation groups, and federal, state, and local agencies. The alliance is addressing the degradation of habitat and water quality caused by erosion, sedimentation, excessive nutrients, and toxic chemicals in the watershed. The alliance has worked with landowners and agency representatives to support enrollment of nearly 200 acres of riparian area in the USDA Conservation Reserve Program. The alliance has also placed over 25 miles of riverbank and streambank under some form of conservation management and planted 11,000 trees.

Cuyahoga River, Ohio—*Restoring an American Heritage River*

The Cuyahoga River drains 813 square miles and travels 100 miles from Geauga County through the Cuyahoga Valley National Recreation Area located between the urban and industrial centers of Akron and Cleveland, before emptying into Lake Erie. The river first caught on fire in 1936. In 1969 a Cuyahoga River fire caught the attention of the nation, and the Cuyahoga became a "poster-child" for the environmental movement. After years of improvement, the Cuyahoga River was designated as 1 of 14 American Heritage Rivers in 1998, but pollution problems remain. The EPA classified portions of the watershed as 1 of 43 Great Lakes Areas of Concern, warranting development of a remedial action plan (RAP).

The Ohio Environmental Protection Agency formed the Cuyahoga River RAP Coordinating

Continued ➤

BOX 10.3—(continued)

Committee, consisting of 33 representatives from local, regional, state and federal agencies, private corporations, and citizen and environmental organizations. The mission of the RAP is to plan and promote the restoration and preservation of beneficial uses of the lower Cuyahoga River through remediation of existing conditions and prevention of further pollution and degradation.

Watershed restoration efforts like river and stream cleanups and biological stream monitoring by volunteers are supported by focused activities based in municipal and township units. The Big Creek Stream Stewardship Program involves locally based education and outreach activities, habitat improvement projects, data collection, and storm drain stenciling.

Noticeable environmental improvements have already been recorded in the Cuyahoga River. Studies in 1998 and 1999 documented usage of the river as a navigation channel for Lake Erie fish migration, including steelhead trout.

Haskell Slough, Washington —*Excavation Resurrects Aquatic Habitat*

Haskell Slough, a system of streams and ponds connected to the Skyhomish River, is an important fish overwintering and rearing area for Puget Sound chinook, coho, steelhead, and chum. In the 1930s, the system was diked upstream, and years of intermittent flooding and silt deposits isolated the system from the Skyhomish River. Land development, roadway construction, and agricultural runoff filled in the channels between the system's ponds, and adult or juvenile salmon washed into the system could not escape.

In 1996, the Haskell Slough Salmon Restoration Project was initiated as a cooperative effort of private landowners and a coalition of nonprofit organizations, Native American tribes, and state and federal agencies. After two years of planning and design, the Salmon Habitat Restoration Project began in 1998. By 1999, a new channel was constructed, and 3.5 miles of river bed was restored by excavating 7,000 feet of stream channels connecting 11 existing large, groundwater-fed ponds. The excavation ensures year-round flow through the entire Haskell Slough. The project also installed rootwads, large woody debris, log weirs, and other structures to enhance the salmon-rearing habitat. Project participants monitor fish traps to track progress and the quantity of fish in the system. In 1999, after 50 years of limited or no production, about 10,000 coho salmon fry were counted swimming into the slough. Adult salmon have returned to the high water in the lower portion of the system. Within four years, several thousand adult coho will be produced by the system, as well as increased numbers of chinook, steelhead, and searun cutthroat.

The core values of the Plan, shown in the following list, illustrate the deep-seated ethical basis for the plan: Seek the truth; respect people and nature; share, act voluntarily, build partnerships, and strengthen community; let rivers be rivers and untame our watersheds. These values appear to have captivated agencies, communities, and citizens and have resulted in considerable action in watershed protection and restoration. This is reflected in the expanding range and number of participants, the increasing funding provided, and the growing number of restoration projects and actions taken since 1995.

Core Values of Oregon Plan for Salmon and Watersheds

Seek truth, learn, and adapt. Our knowledge of the world is imperfect. Understanding and behavior must evolve over time.

Be humble. Remember, Mother Nature does not answer to salmon or man. Both survive at her discretion.

Obey the law and live up to commitments. Honorable behavior earns trust. Get busy and earn it.

Respect people, respect nature. The two are inseparable.

Act voluntarily. Do one's best each day. Miracles don't spring from just trying to get by.

Exercise patience. Salmon have survived here for thousands of years. Our work won't be complete in a month, a year, or a decade. Our challenge is to build a world where both salmon and people can flourish on a greater time scale than most people comprehend.

Build partnerships, make friends, and strengthen community. No single person or organization has the power or understanding needed to keep the world safe for us all. We need each other.

Strive to let rivers be rivers, and untame, a little, our watersheds. People have changed the land and changed the waters of the West in ways that do not respect salmon or people. We must undo some of these changes to maintain a world in which we can thrive.

Share. Share information. Share the power to make decisions. Share the responsibility to act.

Consider our children's needs. They will inherit the world from us.

Never give up hope.

Principles of the Oregon Plan and Use of the Tiered Approach

The basic principles of the OPSW include the elements of watershed and ecosystem management:

- *Community-based Action:* Local watershed councils, soil and water conservation Districts (SWCD), landowners, and other grassroots players perform the key roles of preparing and implementing actions, as well as monitoring and improving them over time.
- *Governmental Coordination:* State and federal laws, policies, and funding programs provide the context, goals, and support for the program; agencies provide the oversight and technical assistance for community-based action.
- *Monitoring and Accountability:* Assessment of work and results is essential to ensure effective use of funds, monitor progress toward program goals, and support adaptive learning.
- *Adaptive Management:* Program participants must learn from the experience of local restoration efforts to enhance understanding of natural systems and improve restoration measures.

These basic principles illustrate the need for a tiered approach: while protection and restoration action is concentrated at the subwatershed and catchment (project) levels, that action must be informed and funded from the regional, basin, and watershed levels by state and federal laws, policies, agencies, and programs. And accountability, shared experience, and adaptive learning requires monitoring, reporting, and information flow from the project level to agencies at the watershed and basin levels. The Oregon case provides an excellent example of this tiered approach.

- *At the regional level:* The Oregon Plan is driven by federal law and mandates in the ESA for listed salmon and other species.
- *At the basin level:* The Northwest Power Planning Council (NPPC) supports work to restore watersheds and salmon populations throughout the Columbia River Basin. In addition, the National Marine Fisheries Service (NMFS) allocates funds to the Northwest states for ESA recovery in the Columbia River and coastal watersheds.
- *At the state level:* The Oregon Plan provides a statewide framework for implementing the federal requirements and enhances recovery of salmon habitat, water quality, and watershed integrity. Several state agencies, such as the departments of Fish and Wildlife, Agriculture, Forestry, Environmental Quality, and State Police (enforcement) play active roles in planning, data management, technical assistance, monitoring, and funding. The Oregon Watershed Restoration Board is the principal state funding agency for subwatershed and restoration project grants.
- *At the watershed level:* Watershed level plans guide subwatershed and project actions. In 1998, the citizen-based Willamette Restoration Initiative (WRI) was established and completed the Willamette Chapter of the Oregon Plan in 2001. The WRI strategy included 27 critical actions needed to protect and restore Oregon's largest and most critical watershed that is home to 70 percent of its population, 50 percent of its agriculture, and native runs of four species listed under the ESA.
- *At the subwatershed level:* The number of local watershed councils grew from a handful in 1993 to 90 in 2001. Working in partnerships with SWCD, these councils provide the critical institutional layer to coordinate catchment projects, apply for funding, and report to state agencies.
- *At the catchment level:* Here is where restoration projects occur. These are conducted by different parties, including state agencies, watershed councils, citizen groups, and landowners. Project reporting also originates here, so that lessons and learning can be shared with others in the watershed and basin.

Funding for Plan Implementation

Successful restoration depends on adequate funding from federal and state sources. Federal sources include the NPPC restoration funding ($100 million per year for the entire Columbia Basin), NMFS ($9–15 million a year to Oregon for salmon ESA Recovery), federal land agencies, and EPA funds for water quality improvement. State legislatively approved biennial funding for watershed restoration increased from $0.5 million in 1987–1989 to $5.5 million in 1996–1997 to $32 million in 1999–2001.

A critical step for state watershed restoration funding was the overwhelming voter passage of Ballot Measure 66, the so-called Salmon and Parks Measure, in

1998. The referendum dedicated 15 percent of Oregon lottery receipts to conservation programs, half to parks and half to salmon and watershed programs. These funds, as well as NMFS recovery funds, are administered by the Oregon Watershed Restoration Board (OWRB) for grants to local watershed restoration projects. In addition to state and federal sources, funding for watershed restoration comes from private industrial forest landowners, nonindustrial landowners, and citizen groups. Between 1995 and 2000 more than $100 million was spent on watershed restoration.

Summary

As we embark on the challenges of managing natural resources, lands, and waters in the new century, two related approaches have emerged as guiding paradigms: ecosystem management and watershed management. These approaches are still evolving, but already they show great promise from considerable experience at both the national and local level in the United States. International experience indicates that they have universal applications.

Ecosystem and watershed management share several common principles. They are fundamentally scientific, aiming to base decisions on the best available technical data and information. They aim also to add to the body of knowledge about natural systems and solutions through experimentation, monitoring and evaluation, and adaptive management. The approaches integrate different scales of space and time. Ecosystem projects may be small in scale but should be viewed as part of larger landscapes. Watersheds are "nested"; catchment projects should be guided by plans for the larger basins that contain them. Plans are guided by history, and have a long time horizon necessary to achieve a sustainable future. Ecosystem and watershed solutions should integrate a range of regulatory and nonregulatory methods into innovative packages that also address compatible objectives like natural hazard mitigation, recreation, water supply protection, and other economic benefits. The solutions aim to both protect and restore natural systems. As such, *management* is a more encompassing term than *protection*.

Finally, these approaches are collaborative, aiming to engage a wide range of participants and stakeholders not only in gathering information and viewpoints, but also in formulating decisions and implementing plans. The collaborative and adaptive nature of EM and WSM is perhaps their greatest quality, the characteristic that will sustain them well into the future. We have seen many examples of how WSM has become a social movement, engaging not only agencies, but also businesses, landowners, citizen groups, and schoolchildren in planning, monitoring, and implementing restoration and protection projects. This will give these approaches their staying power as they develop social, intellectual, and political capital. In addition, their adaptive nature fosters change, improvement, and evolution as participants learn better ways to provide for the needs of people within functioning natural ecosystems.