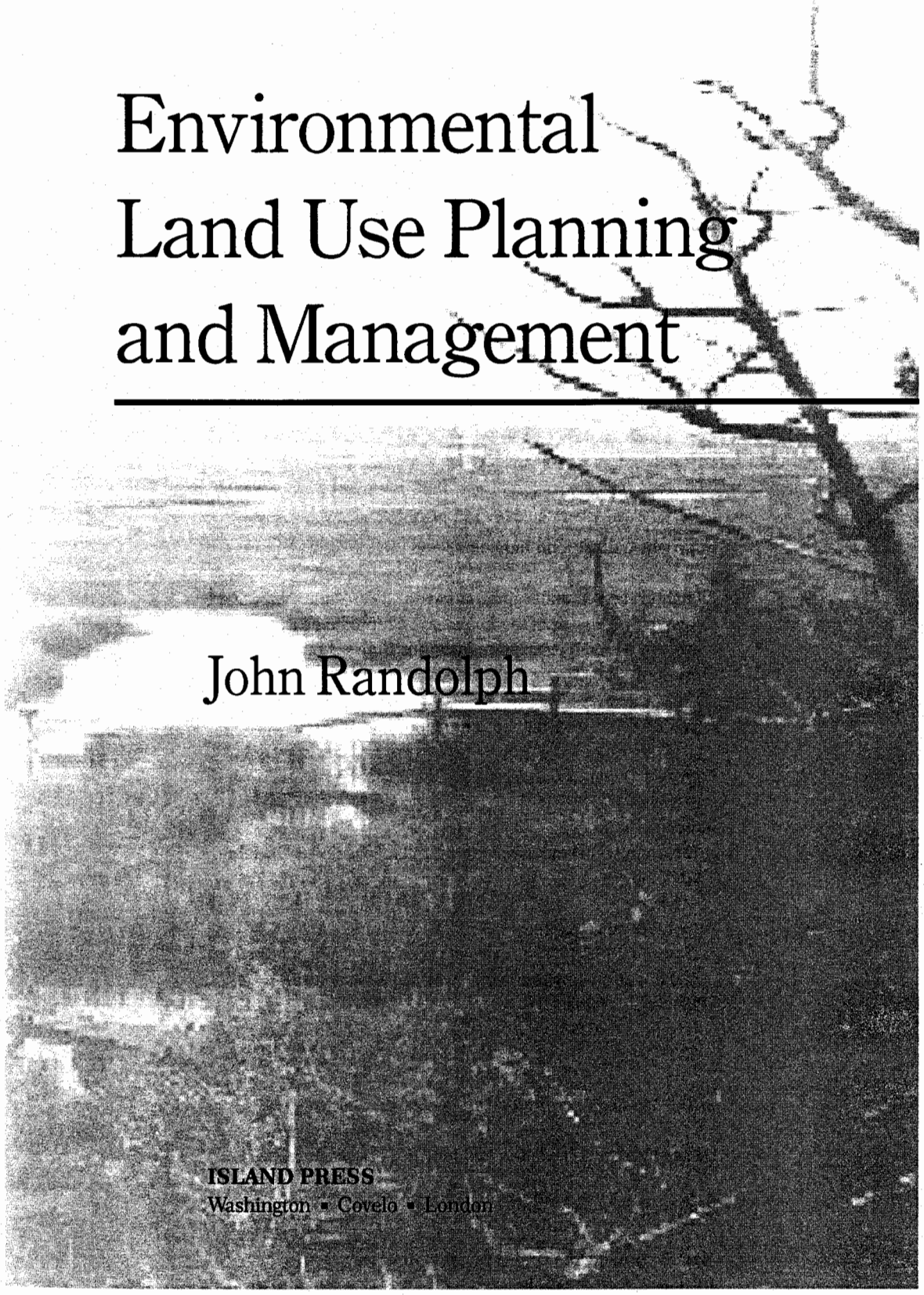
Environmental Land Use Planning and Management



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- **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).

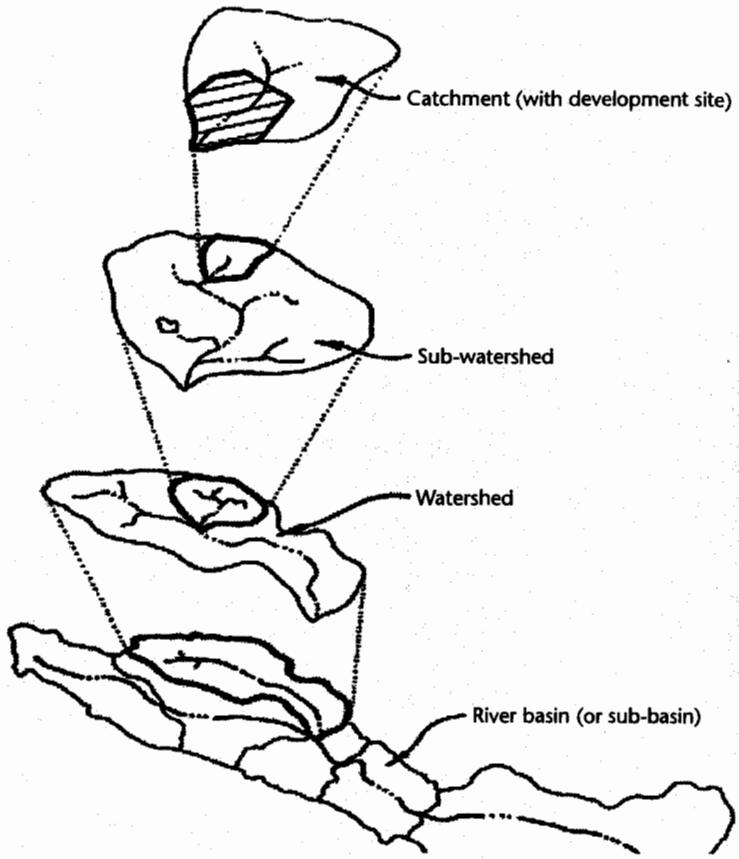

Figure 10.4 Nested Watersheds. *Source:* Adapted from Schueler (2000).

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 (mi^2)*	*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.