Watershed Management Perspectives in the Southwest: Past, Present, and Future

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Abstract.—Watershed management perspectives in the Southwest have been, are, and will be reflected by the nature of watershed management practices. Past perspectives evolved from considerations of increasing water yields and water quality concerns. Present perspectives are centered on minimizing adverse impacts to soil and water resources, sustaining high-quality water flows, and rehabilitating watershed in poor condition. Future perspectives will likely focus on an increase in demand for watershed resources, more efficient use of limited watershed resources, and more efficient management of available watershed resources. These perspectives are more specific than global and national perspectives, which is expected when focusing on a specific biogeographic and socioeconomic setting.

Introduction

Watershed management perspectives presented at global and national levels also apply to the Southwestern region of the United States. Issues identified by Brooks and Eckman (this publication) at the global level, and Adams et al. (this publication) at the national level, such as water scarcity, water pollution, and a scarcity of land and natural resources, enhance consideration of past, present, and future watershed management perspectives in the Southwest.

At all levels of perspectives, watersheds are effective planning units for ecosystem-based, multiple use natural resources management practices, projects, and programs (Adams et al. this publication, Brooks et al. 1992, Lopes et al. 1993, and others). However, as pointed out by Adams et al., continued use of watersheds in a planning capacity will depend on whether natural resources management issues are prioritized by decisionmakers. In addition, the ability of competition for consumptive natural resource use, advancing appropriate technologies, and developing effective land-use policies to be adequately balanced will affect the continued planning use of watersheds. These are certainly relevant to the Southwest.

Past, present, and future perspectives of watershed management in the Southwest, reflected by the nature of watershed management practices, are considered in this paper. These perspectives of watershed management are more specific than global and national perspectives, which is expected when focusing on a specific biogeographic and socioeconomic setting.

The Southwest Setting

The Southwest, which includes Arizona and New Mexico, and portions of Nevada and California, has broken and diverse topography. Isolated mountain ranges are separated by valleys, plains, or desert floors. Forest and woodlands cover the mountains, while mostly shrubland ecosystems and a diversity of floristic communities common to the warm-temperature Chihuhuan and Sonoran Deserts are found at low elevations. Soil parent materials are volcanic basalts, sedimentary rocks, and granitic in complex layers. These soils are shallow, often infertile, and moderately erodible.

The region receives an average of 330 mm of annual precipitation, mostly in 2 seasons. About 60% of the annual precipitation occurs in the winter, often as snow at the higher elevations. Winter precipitation is associated with frontal storms from the Pacific Northwest. The major source of moisture for summer rains is the Gulf of Mexico. As it moves into the region, this moisture passes over mountainous terrain, which causes it to rise, cool, and condense into intense, localized convectional rainstorms.

Mixed conifer forests of Douglas fir, ponderosa and southwestern white pine, white and corkbark fir, Engelmann and blue spruce, occupy 160,000 ha of wet, cool sites at the highest elevations in the region (2,100 to 3,000 m). Precipitation at these elevations averages 630 to 760 mm, of which more than half is snow. Streams originating above 2,900 m are often perennial, while those beginning at lower elevations are mostly intermittent. Preferring warmer and drier sites than mixed conifer forests, lower-

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elevation ponderosa pine forests occupy 2.4 million ha between 1,800 and 2,700 m. Annual precipitation on these sites averages 500 to 630 mm, equally divided between rain and snow. The mostly ephemeral streamflows originate largely from snowmelt.

Pinyon-juniper and evergreen oak woodlands occupy 8.2 million ha of intermediate-elevation lands between the higher forest types and lower desert ecosystems. Summer rains account for about half of the 300 to 450 mm of annual precipitation. Streamflows are generally less than 25 mm, although it can approach 75 mm on better water-yielding sites.

Interior chaparral shrublands cover about 1.4 million ha of discontinuous mountainous terrain south of the Mogollon Rim in Arizona; chaparral shrublands are limited in extent elsewhere in the Southwest. Average annual precipitation ranges from about 380 mm at the lower elevations to 630 mm at the higher elevations. Streamflows from these sclerophyllous shrublands average 25 mm, but varies greatly with precipitation, elevations, and soils.

Desert shrublands of numerous shrub species and cacti are delineated into northern and southern types. The northern desert shrub type is largely confined to elevations between 750 and 1,500 m, while the southern type is found mainly at elevations of 90 to 900 m. Annual precipitation ranges from 125 to 350 mm for the northern shrub type and 75 to 300 mm for the southern shrub type. Streamflow is negligible. Desert shrublands are adjacent to and often intermingle with desert grassland types at almost all elevations.

Riparian ecosystems (narrow bands of trees, shrubs, and herbaceous species along stream systems) are found throughout the region (Baker 1999, Baker et al. 1998). These ecosystems are often of special interest to the public because they consume large amounts of water (thereby reducing streamflows), represent conveyance systems for streams originating on upland watersheds, possess high scenic value, and provide critical wildlife habitats and recreational opportunities. Restoration of degraded riparian ecosystems is a high priority watershed management activity.

The Southwestern United States is one of the fastest growing regions in terms of human populations. Much of this continuing growth is due to the substantial migration of people into the region from the Midwest, the South, and elsewhere in the West. Although the population is concentrated in the larger metropolitan areas of Albuquerque, Phoenix, and Tucson, city dwellers escape the summer heat by traveling to higher, cooler forests. The Southwest enjoys relatively high incomes, low unemployment, and increasing amounts of leisure time. These conditions serve to accelerate the demand on the region's natural resources.

Past Watershed Management Perspectives

By the middle of the 20st century, when intensive management of watershed lands began in the Southwest, watershed management perspectives closely paralleled those at the national level (Neary this publication). It was thought, for example, that watershed management of forests, woodlands, shrublands, and untilled grasslands could be accomplished to improve water supplies. An early emphasis of watershed management was the importance of water as a commodity. Therefore, practices were largely centered on increasing water yields to downstream users through forestry-related and other vegetation management interventions. Intensive research efforts followed by operational programs began at this time and, to some extent, are still conducted on these important watershed-management topics.

Increasing Water Yields

Watershed management practices from the early 1940s through the beginning of the 1980s focused largely on increasing water yields through vegetation management on upland watersheds. Water-yield improvement tests were conducted on experimental watersheds located mostly in Arizona. If the experiments proved successful in increasing water yields, they were implemented operationally. Clearcutting, other silvicultural treatments, and conversions from high water-consuming vegetation to low-consuming vegetation were tested (figure 1). These experiments demonstrated that water yields originating on upland watersheds could be increased (to varying magnitudes and duration) by changing the structure and compositions of the vegetative cover on a watershed (Baker 1999, Baker and Ffolliott this publication). Additional water yields, when obtained, were attributed largely to decreases in transpiration rates.

An analysis by Hibbert (1979) showed that vegetative manipulations could increase water yields only on watersheds receiving more than 480 mm of annual precipitation. He reasoned that precipitation below this amount is effectively used by any residual overstory vegetation and subsequent increases in herbaceous plant cover on the watersheds. This finding, along with other analyses of water-yield improvement potentials, suggested that in the Southwest, high-elevation mixed conifer and ponderosa pine forests and portions of low-elevation chaparral shrublands have the best theoretical potentials for increasing water yields through vegetation management.

Figure 1. Heavy thinning of a ponderosa pine forest to increase water yields and enhance other multiple-use values.

However, beginning in the late 1970s, increasing environmental concerns have curtailed large-scale implementation of many of the vegetation management practices proposed for water-yield improvement.

Water Quality Concerns

Emphasis shifted by the late 1970s from strictly considering water-yield improvement to concerns about the quality of the water originating on upland watersheds; this remains the focus today (Ffolliott et al. 1997). Part of this concern evolved from the increased public awareness of environmental quality issues in natural resources management. This heightened level of concern is exemplified by passage of the National Environmental Policy Act, the Clean Water Act, and creation of the Environmental Protection Agency in the early 1970s. Watershed management took on the added dimension of ensuring that whatever practices were implemented considered physical, chemical, and biological qualities of water in steams from upland watersheds.

Present Watershed Management Perspectives

Watershed management perspectives in the Southwest are now largely framed by the watershed management approach to land stewardship, which recognizes the importance of land productivity as an integral part of watershed management. This approach incorporates soil and water conservation and land-use planning into a broad, logical framework by focusing on the influences of people; recognizing that the effects of these influences often follow watershed, not political, boundaries; and appreciating that actions taken on upland sites often impact downstream areas (Brooks et al. 1992, and others). Watershed management now recognizes the interrelationships among land use, soil and water, and the linkages between uplands and downstream areas.

Presently, watershed management practices are grouped into 3 general categories. These categories are practices that minimize any adverse impacts to the soil and water resources (thereby sustaining the status of watersheds in good condition), sustain high-quality water flows originating on upland watershed lands, and rehabilitate watersheds to increase productivity (Baker 1999, Baker et al. 1995, Lopes and Ffolliott 1992).

Minimizing Adverse Impacts

Because of fragile soils and limited water, it is important to protect the watershed lands in the Southwest from further deterioration of soil and water resources. Past degradation, often widespread, has been attributed to overgrazing, fire suppression, and both high intensity rains and prolonged droughts. Watershed management practices, similar to those used to prevent excessive rates of initial erosion, are implemented to reduce further degradation of watershed resources.

Road construction is prohibited in or near stream channels. When roads are closed to public travel, the roadways are seeded with herbaceous plant species to protect against erosion. Timber harvesting in the Southwest has recently been sharply curtailed, largely in response to environmental concerns. The limited logging that occurs is often restricted to periods of excessive rainfall. Livestock grazing and recreational use is continually monitored to determine if and when remedial actions should be taken to minimize the impacts of these land uses on stream channels, riparian ecosystems, and water quality. Prescribed burning and a variety of mechanical control treatments are imposed to reduce excessive fuel accumulations on sites prone to wildfire (Edminster et al. this publication). These actions are essential components of integrated watershed management to maintain watersheds in a good condition; accommodate ecosystem-based, multiple-use management programs; and address the increasing public concern about threatened and endangered plant and animal species.

Sustaining High-Quality Water Flows

Sustaining high-quality water flows from upland watersheds is a major focus of watershed management. Water shortages, always present in the Southwest, will likely become even more limited in the future as human populations increase. While large-scale manipulations of vegetative cover to specifically meet past water-yield improvement objectives are not planned, a custodial management strategy to maintain the health of the forests, woodlands, and shrublands in the region is paramount (Baker 1999). These management practices, once again, are consistent with sound land stewardship.

Best Management Practices (BMP) are often selected as the approach to sustaining high-quality water flows. The BMP approach involves identification and implementation of watershed management practices to reduce or prevent nonpoint pollution (Brown et al. 1993). Many of these practices are well known for erosion-sedimentation processes concerning agricultural, forestry, and road construction activities (Brooks et al. 1997). The BMP for mitigating some types of pollutants, however, are not known.

Watershed Rehabilitation

Concern for the declining health of watershed lands has led to implementation of management practices to restore the proper hydrologic functioning of degraded watershed lands. Management practices to rehabilitate watersheds in poor condition include controlling gullies and mass wasting with properly constructed check dams and other mechanical controls; protecting unstable stream channel from further damage (figure 2); establishing protective tree, shrub, or herbaceous covers on degraded sites; and further curtailment of timber harvesting, livestock grazing, and other exploitative land-use practices. Presently, restoring riparian ecosystems to retain their hydrologic equilibrium is a major focus of watershed management (Baker 1999, Baker et al. 1998).

In the Southwest, artificial seeding of herbaceous plant species on degraded watershed sites has been studied for nearly a century. Thames (1977), Cox et al. (1984), Oechel (1988), Roundy (1995), and others found that a variety of perennial grasses and forbs can be successfully established on sites needing rehabilitation. The results of these studies provide managers with information necessary to restore severely degraded watershed lands to more productive conditions by establishing a protective vegetative cover. Even though revegetation is difficult and costly, it is possible. However, frequent drought and continual human abuse of some lands continues to cause the deterioration of fragile watersheds through accelerated erosion, invasion of noxious plants, and reduction of plant growth in general.

Many sensitive ecosystems in the Southwest are delicately balanced within an environment having limited water and a highly variable climate. This balance has frequently been overwhelmed by past land-use practices, resulting in severe and widespread watershed degradation. Careful implementation of watershed and hydrologic information has successfully restored some highly

Figure 2. Protecting unstable stream channels by placing rocks on channels walls.

degraded sites. However, more intensive applications of known technologies will depend largely on a more thorough understanding of the fundamental hydrologic processes operating in this unique environment.

Future Watershed Management Perspectives

Future watershed management perspectives in the Southwest, and elsewhere in the nation, will likely represent a more holistic approach to managing the biological, physical, and social elements on a landscape delineated by watershed boundaries. Watershed management practices must be based on the art and science of managing natural resources on a watershed-basis to provide goods and services to society without adversely affecting the basic soil and watershed resources. Watershed management in the Southwest must broaden its traditional focus on wildlands to include the urban fringe and urbanized areas to content with anticipated population needs.

Continuing Emphasis on Watershed Improvement Practices

Future watershed management practices will continue to minimize adverse impacts, sustain high-quality water flows, and rehabilitate watersheds in poor conditions. It is likely that these practices will be intensified as continuing monitoring activities indicate that additional watershed lands require remedial actions to restore properly functioning hydrologic processes (Baker et al. 1998). Implementation of BMP should help achieve these objectives.

Increasing Emphasis on Demands for Watershed Resources

Much of the watershed-research effort in the past and, to some extent, in the present has focused on the supply-side of watershed management; for example, attempting to increase high-quality water flows from watershed lands. Other approaches to increasing water supplies have also been explored including water harvesting and spreading, gaining access to deep aquifers, increasing storage reservoir capacities, and changing storage techniques to reduce evaporation (Gregersen et al. this publication). These supply-side efforts will continue to be a focus of watershed management where realistic opportunities are present. However, watershed management practices must also emphasize the demand-side of the resource-availability equation.

Efficient Use of Limited Watershed Resources

The benefits of watershed management will become evident through increased efficient use of the limited watershed resources in the Southwest. To paraphrase Gregersen et al. (this publication), greater efficiency in watershed resources use is likely to be attained by changing technologies to those that more efficiently and effectively use these resources. Providing people with greater responsibility over their use of limited watershed resources to encourage conservation is also needed. Increasing the prices of watershed resources (water, timber, livestock forage, wildlife habitats, and recreational opportunities) to reflect their true scarcity-value and the costs of supplying them, is also necessary.

Efficient Management of Available Watershed Resources

Focusing on improving management of available (existing) supplies of water and other watershed resources despite progress made to increase the supply or reduce the demands for these resources will be necessary. More effective applications of known technologies should be encouraged; watershed-management technologies must be improved; effective technology transfer mechanisms should be developed; and increased public awareness of the need to balance the economic and environmental values of available watershed resources will be required.

Summary

Past perspectives of watershed management in the Southwest evolved from a desire to increase water yields to addressing water quality concerns. Present perspectives are centered on minimizing adverse impacts to soil and water resources, sustaining high-quality water flows, and rehabilitating watersheds in poor condition. Future watershed management will likely become more holistic than what presently exists. This will occur through increased emphasis on the demands for watershed resources and more efficient use of limited watershed resources and management of available watershed resources. With broad public participation, this integrated vision must be the future focus of watershed management to effectively respond to people's concerns about improved land stewardship in the 21st century.

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