CHAPTER 14

Water Availability and Recreational Opportunities

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CONTENTS

Recreation helps maintain physical and emotional health and enhances the quality of life. Much of the nation's recreation activity occurs out of doors.[1] The Southwest's bounteous forests, woodlands and deserts provide ample outdoor recreation opportunities, a reason for the region's rapidly expanding population. Outdoor recreation is important to city dwellers, many of whom crave temporary escape from their urban surroundings, and to rural inhabitants, some of whom choose to live away from the city partly to be close to outdoor recreation opportunities.

Riparian areas act as magnets for outdoor recreationists, particularly in the arid Southwest. People flock to riparian areas for active pursuits such as boating, fishing, hiking and camping and also simply to see and be close to the water and its

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surrounding riparian vegetation. Use of southwestern riparian areas for recreation and renewal has increased dramatically over the past 50 years in concert with the general increase in recreation participation.[1] The demand for access to riparian areas for recreation has grown at the same time as the Southwest's expanding population has swelled the quantity of water diverted for off-stream uses.[2] The mounting diversions have reduced the very streamflows upon which riparian recreation depends. These conflicting trends of increasing demand for and decreasing supply of instream flow have raised the importance of understanding how recreation quality varies with water flow. Only with a good comprehension of this relation can the tradeoffs between competing water uses be carefully evaluated. This chapter reviews what has been learned about this relation.

Streamflows have both direct and indirect effects on recreation.[3] Direct effects exist in real time. Extant flows affect the quality of rapids for boating, anglers' access to the site and catch rate, and the scenic beauty of a river scene. Indirect effects help create the conditions of future recreation opportunities. For example, flows, specifically periodic high flows, help maintain gravel bars for camping, control encroaching vegetation to ensure scenic visibility and help maintain channel form and function and, as a result, fish habitat. Most studies of direct effects have been based on experts' or recreationists' evaluations of recreation quality, whereas studies of indirect effects emphasize scientists' descriptions of physical processes. The primary focus of this chapter is on the direct effects of flows on recreation, but several indirect effects are also briefly mentioned. The processes involved in indirect effects are discussed in more detail in several other chapters of this book. Flows directly affect two categories of recreation activities, streamflow-dependent activities and streamflow-enhanced activities.

14.1 STREAMFLOW-DEPENDENT RECREATION

14.1.1 Boating

Streamflow-dependent recreation activities are impossible without adequate instream flow. These activities include boating, wading, swimming and fishing. Boating is among the most popular of riparian recreation activities. Powerboats, sailboats, canoes, kayaks, dories, rafts, tubes and a variety of other engine-, wind-, oar-, self- and river-powered vessels are used to float on rivers in the name of fun and recreation. Beyond enabling the existence of such activities, streamflow directly affects the quality of a recreational boating experience through its effects on floatability, rapids, rate of travel and safety.[4]

At a minimum, boating requires enough water for the boat to float and move. *Floatability* is the capacity of the river to support boating without excessive hits, stops, drags and portages. Running into rocks, river bottoms, trees or other obstacles can damage vessels and injure passengers. Excessive delays and effort expended in prying boats off obstacles, stopping to disembark, portaging or taking other evasive action can likewise decrease the quality of the recreational experience. Minimum flows on any reach of river differ by type of craft and boater skill level. A unique

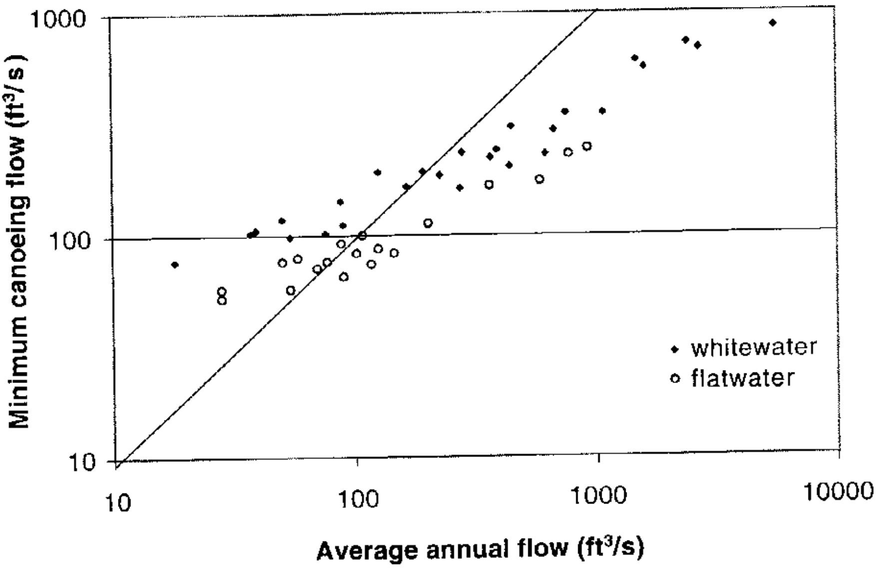

Figure 14.1 Minimum flow requirements for canoeing (from Corbett[5]). Note: Two of the rivers were assessed at two points each, yielding a total of 46 data points for the 44 rivers, 19 points from flatwater streams and 27 from whitewater streams.

study of floatability for canoeing, based on data from numerous rivers, was performed by Corbett.[5] Although the rivers he studied are outside the Southwest, the study is worth summarizing here because it demonstrates principles that undoubtedly apply in the Southwest as well.

Corbett studied "canoeing zero" flow, the flow below which a stream cannot be paddled without frequent walking in shallow reaches. Canoeing zero flow is essentially the minimum flow reasonably needed for canoeing. Some of the rivers that Corbett studied had established canoeing zero gauges at a key point along the river, expressing the consensus of local canoeists. Elsewhere, the author and his cooperators floated the river at various flow levels to estimate canoeing zero flows. Corbett related these minimums to their respective average annual flows and found linear relations in log-log space for both flatwater and whitewater streams (Figure 14.1). Flatwater streams had bottoms characterized by silt, sand, or small gravel, whereas whitewater streams had bottoms characterized by cobbles, rocks, boulders, or bedrock.

Three basic principles are illustrated in Figure 14.1. First, the smaller the stream, the larger the proportion of mean annual flow needed for canoeing. Above-average flows are needed in small streams (data points to the left of the 45° line, Figure 14.1), indicating that the floating season is limited to above-average runoff times of the year. Canoeing is possible in larger streams during below-average flows and, therefore, over more of the year. In other words, the larger the stream, the longer the floating season, all else being equal.

Second, more water is required for canoeing in whitewater streams than in flatwater streams. Regressing (log transformations of) minimum canoeing flow (Qm) on average annual flow (Qa) and type of stream (T) using Corbett's data produced the following equation:

$$Qm = 11.22 \cdot T^{0.702} \cdot Qa^{0.442}, \text{ where } T = 1 \text{ for flatwater and 2 for whitewater } (R^2 = 0.96)$$

From this equation, on average 63% ($2^{0.702} = 1.63$) more flow is required for canoeing on whitewater streams than on flatwater streams.

And third, for both types of rivers, there is considerable variation in minimum flow among rivers of the same average flow. For example, at Qa = 100 ft^3/s, the 95% confidence interval on the predicted Qm of 86 ft^3/s for flatwater is 63 to 118 ft^3/s. For whitewater, the 95% confidence interval on the predicted Qm of 140 ft^3/s is 102 to 192 ft^3/s. Furthermore, additional variation might be introduced if the study were widened to include other geographic areas with rivers of different morphology from the 44 included in Corbett's study. Therefore, a precise estimate of minimum canoeing flow is not possible with this equation. If precision is needed, a careful on-site study must be performed, or a more sophisticated model with additional explanatory variables must be developed. Nevertheless, the equation is useful for obtaining a rough estimate of minimum flows for canoeing and for characterizing general relationships of minimum to average flow.

Minimum flows are not necessarily optimum flows. Floatability improves with flow level, as does overall boating quality, up to a point. Several investigators of single reaches of river have evaluated a range of flows for overall boating quality, revealing optimum flow levels. Shelby and Whittaker[6] did so for the Upper Canyon of the Dolores River in southwestern Colorado, a popular whitewater reach downstream from McPhee Dam. They surveyed four groups of experienced floaters of the Upper Canyon, specifically users of canoes, small rafts, large rafts and kayaks. All respondents were asked to evaluate 15 different flows (from 150 to 5000 ft^3/s) on a five-point rating scale ranging from one (unsatisfactory) to five (satisfactory), with a three labeled neutral. As seen in Figure 14.2, optimum flows for canoeing (about 700 to 1000 ft^3/s) were lower than optimum flows for small rafts (about 1000 to 1500 ft^3/s), which were lower than those for large rafts or kayaks (roughly 2000 to 4000 ft^3/s). Respondents to the Dolores River boating survey were also asked to estimate "the minimum flow you need to float the river." Mean responses were close to the neutral level in Figure 14.2, with minimums for canoes at about 300 ft^3/s, for small rafts at about 800 ft^3/s and for large rafts and kayaks at about 1000 ft^3/s. Clearly, minimum boating flows on the Dolores are far below optimum flows (though beginners might prefer somewhat lower flows than did the experienced boaters surveyed for this study).

Overall boating quality depends on several considerations, three of which are rapids, rate of travel and safety. Rapids test skills, provide thrills and require whitewater. Whitewater is caused by a combination of streamflow velocity, channel form and channel obstacles, all of which are influenced by streamflow volumes. However, the relationship is not always a simple one and varies considerably among individual rivers and river reaches. Large streamflow volumes with high velocities are occasionally necessary to wash debris into the river, increasing the potential for whitewater. However, in real time, extremely high flows increase water depth, cov-

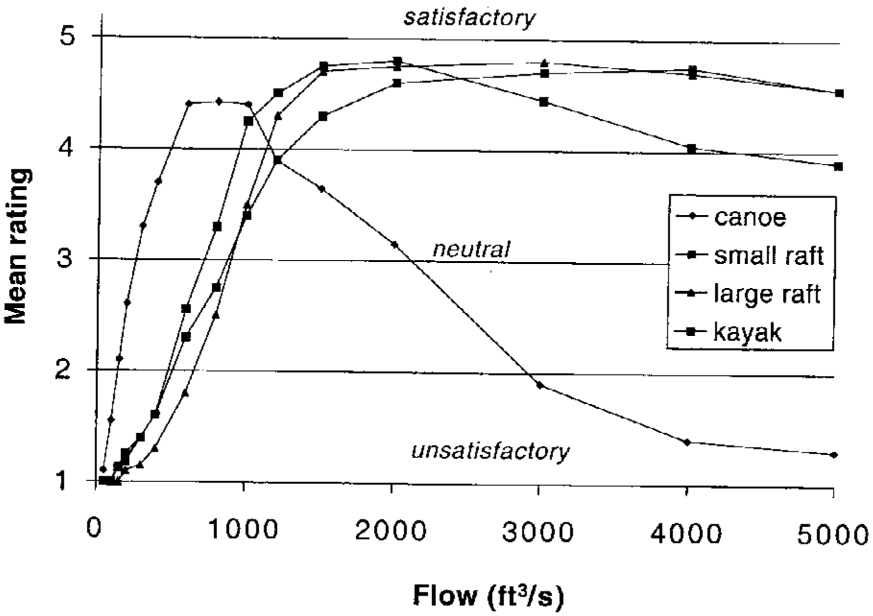

Figure 14.2 Overall flow evaluations for different craft, Dolores River, Colorado. (Shelby, B., Whittaker, D. and Hansen, W.R., Streamflow effects on hiking in Zion National Park, Utah, *Rivers*, 6 (2), 1997. Reprinted with permission from S.E.L. and Associates.)

ering many obstacles and thus reducing rapids. Smaller volumes expose more obstacles and thus provide better rapids. If volumes are too small, the power and velocity of the flow are below optimum. In between such extremes, opportunity for good rapids is maximized.

The rate of travel is most important on rivers with a limited number of access-exit points for boaters who are embarking on full-day or multiday trips. Rate of travel is influenced by streamflow velocity and the floatability and whitewater characteristics discussed above. Large streamflow volumes yield high streamflow velocities, so an increase in streamflow likely causes a decrease in travel time.

Safety, that is, the absence of accidents such as losing equipment, damaging a boat, or falling out of the boat and risking personal injury, also varies with flow level. Shelby et al.[7] surveyed Grand Canyon river guides about the likelihood of an accident. Accidents are least likely at medium flows (Figure 14.3). At low flows, rapids are more difficult to negotiate and, at high flows, the water moves too swiftly and the few exposed beaches are more difficult to access.

In general, direct effects of flows on overall trip quality and specific characteristics such as whitewater rapids and safety tend to exhibit a concave (inverted U) shape when plotted with quality or safety or other desirable characteristic on the vertical axis and flow level on the horizontal axis.[8,9] Starting from minimal flows, benefits increase with flow. As flows continue to increase, the rate at which benefits increase diminishes. Total benefits eventually plateau and then decrease. This common characteristic supports the claim of water resource managers that flows

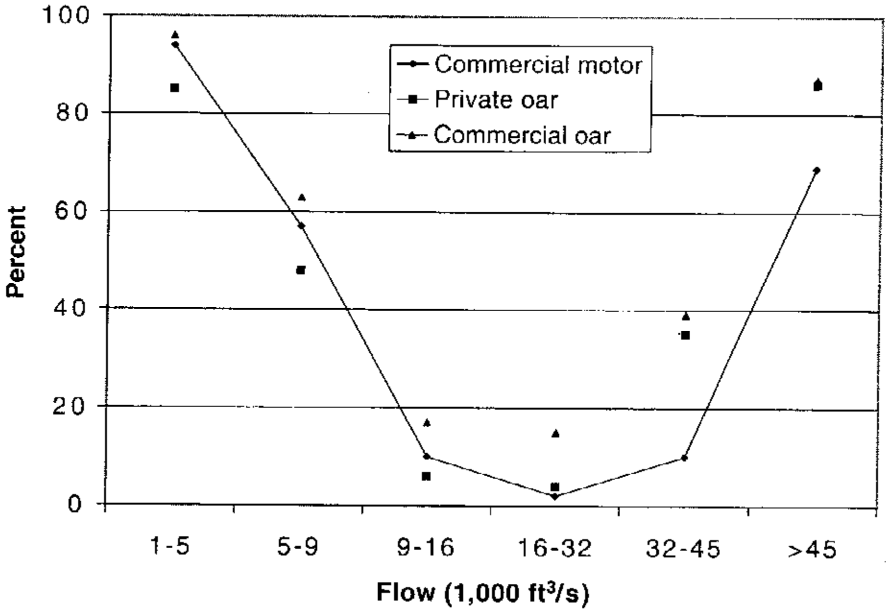

Figure 14.3 Percent of respondents who think accidents are more likely to happen at constant flow level, Colorado River in Grand Canyon National Park (Shelby, B., Whittaker, D. and Hansen, W.R., Streamflow effects on hiking in Zion National Park, Utah, *Rivers*, 6 (2), 1997. Reprinted with permission from S.E.L. and Associates.)

must be carefully assessed to determine the level of greatest benefit. Minimum flows do not necessarily provide the greatest benefit.

14.1.2 Wading and Swimming

Virtually everyone has been swimming or wading in a stream or lake. Streamflow volume directly affects the quality of these recreational experiences through its influence on water depth, velocity and temperature. The most desirable depth depends on the particular activity and the skill of the participant. Swimmers need enough depth to avoid touching the bottom. Streamflow just sufficient to fill river pools and create swimming holes are ideal. Diving requires substantially greater depths, while people who are wading or playing in the water usually prefer, and are safer in shallower water.

At high streamflow velocities, swimmers or waders risk being swept downstream or into obstacles such as overhanging trees and submerged or protruding rocks. Lower velocities are best for small children and those with less skill or experience. But, the velocity should be high enough to keep water quality fresh and to provide challenges for those who wish to test their skills. Streamflow temperature generally decreases with streamflow volume, largely because greater volumes mean higher velocities and generally lower surface-to-volume ratios, both of which decrease the warming effect of the sun. At low volumes, temperatures in the Southwest can be too warm for the water to be refreshing. At high streamflow volumes temperatures can be uncomfortably cold, especially at high elevations.

Swimming suitability along the Clavey River near its confluence with the Tuolumne River in California was assessed in preparation for Federal Energy Regulatory Commission (FERC) deliberations about a proposed dam.[10] Ten pools were assessed at each of eight flow levels. Flows of 10 to 250 ft^3/s were found to be acceptable, flows of 20 to 50 ft^3/s were optimal and flows above 350 ft^3/s were unsafe. However, by late summer, after several weeks of flows below 20 ft^3/s, water quality declined so that flows between 10 and 20 ft^3/s also became unacceptable. Again, an inverted-U relation of quality to flow generally prevailed. Quality improved with flow to a point and then decreased at higher flows.

14.1.3 Fishing

Good fishing depends largely on healthy fish populations and, therefore, on the streamflow conditions that support those populations. Streamflow-dependent variables important to fish populations include temperature, cover, food supplies and turbidity. Other influences on fish populations besides instream flow include the riparian vegetation, channel structure and form, patterns and quantity of deposited sediment, winter snow and ice accumulation, the presence and concentration of potentially toxic chemicals, nutrient and energy cycles, interactions between fish and invertebrates, competition with and predation by other fish and predation by birds and mammals, including humans (see Chapters 9 and 13). The importance of instream flows is evident even here, however, because these other factors are affected to varying degrees by instream flow.

Good fishing also depends on availability of locations for fishing. Occasional high water flows help keep river banks and point bars free of vegetation and, as a result, provide ease of movement up and down the river and adequate space for casting. The direct effects of water flows on fishing include those on access, fish activity and safety. Flows of wadeable depths and velocities allow fishing from within a stream channel. Though fish activity tends to increase with higher flows, activity tapers off at very high flows. Safety is threatened if flow levels rise too quickly, as anglers could be left stranded or faced with life-threatening situations.

The most desirable streamflow regime depends on the fishing type. Ideal conditions for bait fishing, spin casting and fly fishing can vary substantially and, therefore, a variety of flows might be necessary to create the most desirable mix of fishing conditions. However, given a certain fish population, fishing quality tends to increase with flows up to a point and then decrease with further flow increases, exhibiting the familiar inverted-U relation.[4]

14.2 STREAMFLOW-ENHANCED RECREATION

Flowing water enriches many recreational activities, including hiking, camping, walking, biking, picnicking, observing birds and wildlife, sightseeing, nature study, photography and just sitting or relaxing. All of these activities benefit from the aesthetic quality of flowing water. Aesthetic effects and one recreational activity, hiking, are discussed below, following a brief mention of some of the indirect effects of flow on recreation.

Hikers, birdwatchers and others who move along a stream or river all benefit from vegetation-scouring high flows that create open banks for traveling. The clearing of vegetation affords bird and wildlife watchers with unobstructed views and enables boaters to access off-river hiking areas. Water flows that create gravel and sand bars in or next to the river give boaters and others a place to camp. These river-scoured and vegetation-free sites are often the only flat areas available for pitching tents and tend to be well-drained and relatively free of insects.

As an example of the importance of streamflows in creating good camping sites, one need only look at the enormous effort and substantial sums of money spent in recent years in the Grand Canyon, where studies attempted to determine the magnitude of sediment loads associated with alternative flow regimes emanating from the Glen Canyon Dam.[11] Several of these studies were designed to assess the impact of flows in creating and destroying beaches and river bars found in the canyon, in part because of the perceived shortage of high-quality campsites along the popular boating river.[12]

Watching birds and wildlife, one of the most popular outdoor recreation activities in the Southwest, is especially satisfying when undertaken around riparian areas. The best streamflows for these activities commonly are those that create the best habitat; that is, flows that lead to the greatest abundance and variety of species create the best opportunities for seeing wildlife. Streamflows that are conducive to the creation and maintenance of wildlife habitat also create good conditions for hunters, especially with respect to habitats suitable for waterfowl.

14.2.1 Hiking

Riparian areas provide some of the Southwest's most popular hiking opportunities. For example, a survey of recreationists who had hiked in the Aravaipa Canyon Wilderness of southern Arizona found that Aravaipa Creek was the most important attribute of their hike, more important than wildlife, vegetation, shade, peace and quiet and eight other attributes.[13] While water is important in general, low flows were often a disappointment. Below the median flow of 23 ft^3/s, the likelihood that flows were judged as less than preferred increased as flow levels dropped. Problems of low flows included shallow swimming holes, exposed mats of dead and drying algae, stagnant pools and a perception of diminished water quality.

In another study, Shelby et al.[14] asked experienced hikers of the Narrows along the North Fork of the Virgin River in Zion National Park to rate the acceptability of various flow levels. Respondents were separated into two groups, those for whom the challenge of negotiating river crossings was important and those less interested in the physical challenges of the hike. Three of the five points of the rating scale were labeled: unacceptable (1), marginal (3) and acceptable (5). In similar fashion to the results for streamflow dependent activities, hikers preferred medium flows to low or high flows (Figure 14.4).

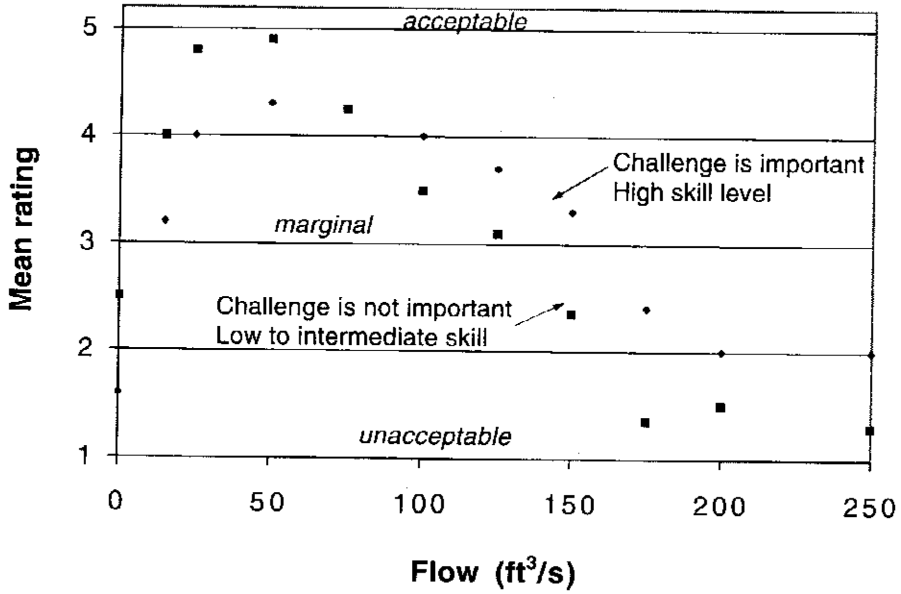

Figure 14.4 Flow evaluation curves for two types of hikers, the Narrows, Zion National Park (Shelby, B., Whittaker, D. and Hansen, W.R., Streamflow effects on hiking in Zion National Park, Utah, *Rivers*, 6 (2), 1997. Reprinted with permission from S.E.L. and Associates.)

14.2.2 Aesthetics

Nearly everyone enjoys the sight and sound of a free-flowing stream. A running stream can contribute to the pleasure, excitement, enjoyment or relaxation experienced by participants in all of the recreation activities considered above. For example, the beauty of the surrounding environment was found to be the single most important factor in providing a good experience for those fishing in California rivers.[15] And not only recreationists enjoy flowing water — anyone who lives by, works by or happens to travel through a riparian area can be touched by its beauty.

Running water expresses a sense of life and vitality. This energy can vary from the vigor of rapids and waterfalls to the steadier and more soothing movement of an ordinary reach of river. Within this picture of movement, attention is also drawn to areas of stillness, and the contrast between pools and riffles or between currents and eddies is visually pleasing.[16] The water surface creates different textures that people find attractive, as it sparkles, reflects images and ripples with the wind.[17] Farther away, rivers and riparian areas are important components of scenic vistas, providing elements of unity, vividness and variety.[18]

Aesthetic quality varies with the level of streamflow. Litton,[16] a landscape architect, observed that aesthetic values of most river reaches tend to be maximized at moderate flow levels. Very high flows can (1) drown out the contrasts between riffles and pools, (2) mask apparent differences of velocity with the impression of a single kind of movement and (3) make islands and point bars disappear. High flows can be turbid and may frighten people with their power or create an unwelcome sense that events are out of control. Very low flows can (1) reduce aesthetic quality by limiting or eliminating whitewater; (2) cause an acute loss of visual and aural qualities at waterfalls, outcrops and boulder dams, creating a feeling of abandonment because the river features are stranded out of the water; (3) decrease the vivid contrast between pools and riffles in river channels composed of massive rocks or boulders; (4) reduce river widths and leave river bars and bed material rather than the river itself as the dominant visual impression; and (5) cause islands and central bars to lose their identities and become mere extensions of the shore. Sudden streamflow declines can reduce aesthetic quality, because people tend to find the resulting "bathtub rings" unsightly.

Brown and Daniel[8] tested the conjecture that moderate flows are preferred aesthetically by obtaining public judgments of the scenic beauty of riparian scenes at 22 points along a 40-mi reach of the Cache la Poudre River in Colorado, each at flow levels ranging from 120 to 2650 ft^3/s. Each scene was represented by a 30-second video sequence. Video, rather than still photography, was used because flow movement and sound affect the beauty of river scenes.[19] Judgments were converted to an interval-scale metric of scenic beauty that was regressed on variables describing flow level and other scene features. Flow explained from 10 to 25% of the variance in scenic beauty, depending on the statistical model. Scenic beauty increased with flow level to about 1300 ft^3/s and then fell as flow increased further. Riparian vegetation also contributed positively to scenic beauty.

The reach of the Cache la Poudre River studied by Brown and Daniel[8] is a mountain stream. Average daily flows on the reach peak in June at about 2000 ft^3/s. Except from May through July, flows are far below the preferred level of 1300 ft^3/s. Flows of 1300 ft^3/s covered the streambed. A scenic preference for a water-covered streambed may not generalize to some other types of river courses such as desert washes. In a report on the San Pedro River in southern Arizona, Jackson et al.[20] speculated that, although recreationists prefer scenes of visibly moving water, aesthetic v alue diminishes once flows are large enough to cover the bed of sandy wash. This conjecture has not been carefully tested.

14.3 MULTIPLE OBJECTIVES OF MANAGED FLOWS

14.3.1 Issues Confronted

Water flows are managed to some extent in nearly all southwestern streams. Dams with storage reservoirs exist on most large streams and offer the greatest degree of control. Even where streams are without dam control, water flow management commonly occurs in the form of diversions to offstream uses. Therefore, management decisions have the potential to affect instream values. Those effects can be either positive or negative. It is interesting to consider what flows would be requested if a mix of recreation and other instream uses were of concern. A problem immediately faced is that flow needs for recreation differ by recreation activity and by skill level within an activity. As seen above, even within a category of recreation such as boating, flow needs differ. The best flow volume for open canoeing is too small for good rafting and the best flow for rafting can be dangerous for swimming.

Conditions for some activities can be provided concurrently, but other activities can only be accommodated in series. The variety of potential activities and user preferences creates a complex mixture of management options that is difficult to assess without considerable knowledge about the unique resource and user conditions along a given reach of river.

An additional complication is that flows needed to help maintain conditions for future recreation opportunities are sometimes different from those desired onsite by recreationists. This complication is especially true of the occasional very high flows needed for channel maintenance. Compromise will always be necessary, for not all requests can be met.

14.3.2 Rio Chama Study

The Rio Chama, a large tributary of the Rio Grande in northern New Mexico, offers an example of an effort to accommodate several instream flow goals. Rio Chama water is used extensively for agricultural and municipal purposes, but the Rio Chama is also one of New Mexico's most popular recreational sites and supports a variety of instream recreational and ecological uses. A 24.6-mi segment of the river between El Vado and Abiquiu reservoirs was designated by Congress in 1988 as a national wild and scenic river. Pursuant to this designation, federal agencies developed a management plan for the river. This plan identified water deliveries to downstream water rights holders as the highest management priority, because the numerous laws, compacts and agreements allocating the river's water predated the wild and scenic designation. However, the existence of numerous dams on the Rio Chama and Rio Grande allows some flexibility in releasing water from El Vado Reservoir, making it possible to meet the needs of several water uses concurrently. Accordingly, the management plan called for a comprehensive instream flow assessment to quantify flows needed to support the various designated instream uses.

The instream flow assessment was performed by a federal interagency group that included the Bureau of Land Management, USDA Forest Service, Army Corps of Engineers, Bureau of Reclamation and U.S. Geological Survey. The group published a report[21] from which this summary was taken. The assessment addressed the following instream flow uses:

- Fisheries
- Recreational boating encompassing 16- and 12-ft rafts, kayaks and canoes
- Fishing, including boating access and the effect of variable flows on fishing success
- Riparian habitat, including the maintenance and regeneration of riparian vegetation
- Scenic-aesthetic qualities of the river, including water quality
- Endangered species, primarily the maintenance of foraging areas for wintering bald eagles and suitable habitat for the eagles' prey species

14.3.2.1 Methodologies

For determining the needs of fish, the interagency group focused on a target species, the brown trout, which naturally reproduces in the Rio Chama and, therefore, also focused on the benthic macroinvertebrate populations that are the trout's primary food source. The group applied established procedures[22] and used data from past studies at several sites on the river. Analysts made recommendations for both optimal and acceptable flow levels. Because desired flow levels varied across the study sites, the flow providing the most total habitat at the different sites combined was chosen as the recommended optimum flow. Riparian vegetation was inventoried and classified by type, extent and age class. Analysts then described and photographed the effects of different flow levels on the vegetation. Several channel cross sections were surveyed and analyzed to determine the relationship between flow levels and channel morphological characteristics. Plots of wetted perimeter versus discharge were developed to determine the flow levels at which the edge of the water started to recede from root zones. Channel cross-sections were used to analyze the effects of high flows on areas containing riparian vegetation. The interagency group determined both the low-flow (for vegetation maintenance) and high-flow (for regeneration) requirements of riparian vegetation.

Experienced fishing guides were taken down the river at different flow levels and asked to evaluate the potential for fishing success. For recreational boating, the interagency group divided the needs of recreational boaters into two categories, scenic and whitewater. Past recreation studies on the river were reviewed and two new empirical studies were performed. First, an onsite user preference survey was performed on weekends during which flows ranging from 800 to 1000 ft^3 were purposefully released from the El Vado Reservoir. Boaters in different craft were asked to evaluate the flow level they had just experienced, using the following categories: more than adequate, adequate, minimum and below minimum. Second, an on-river navigability assessment was conducted of 14 river segments considered the most critical for navigation. Experienced boaters used a variety of craft to run the river at several controlled flow levels. Each boater filled out a navigability assessment form after floating through each of the critical segments. In addition, for later assessment, videos were taken of the craft moving through the identified critical segments at different flow levels. Minimum flows necessary to sustain aesthetic characteristics were ascertained using plots of submerged river bottom (wetted perimeter) versus discharge. The selected flow level was the flow below which wetted perimeter decreased sharply with further decreases in flow.

Three methods were employed to study the flow needs associated with bald eagles. First, analysts compared historical census data of bald eagle populations with streamflow data to determine any significant trends. Second, they analyzed the flow dependency of bald eagle prey species (fish) at riffle-run complexes at three different flow levels using instream flow incremental methodology. Third, analysts used models to estimate winter ice cover and turbidity at different flow levels, because the visibility and accessibility of prey fish species depends in part on the degree of ice cover and clarity of the water.

14.3.2.2 Results

The flow levels recommended by study participants for designated recreational resources are presented in Table 14.1. It is interesting to note the many potential

Table 14.1 Flow Regime Necessary To Support Designated Recreational Resources in the Rio Chama in Northern New Mexico

Resource	Flow Magnitude and Timing
Fish habitat (brown trout)	150–700 ft^3/s, October 15 to March 31 (400 ft^3/s optimum) 150–300 ft^3/s, April 1 to August 31 (200 ft^3/s optimum) 75–300 ft^3/s, September 1 to October 14 (200 ft^3/s optimum)
Macroinvertebrates	185 ft^3/s minimum
Scenic/aesthetic	40 ft^3/s minimum
Whitewater boating	800–1,000 ft^3/s
Scenic boating	500–600 ft^3/s
Fishing	150–300 ft^3/s
Riparian (maintenance flow)	185 ft^3/s, April 1 to September 30
Riparian (regeneration flow)	5,000 ft^3/s at least one day every 5–10 years, between May 15 and June 15
Bald eagles	150–250 ft^3/s, December 1 to March 1

Source: Fogg, J.L., Hanson, B.L., Mottl, H.T., Muller, D.P., Eaton, R.C. and Swanson, S., *Rio Chama Instream Flow Assessment,* USDI Bureau of Land Management, Denver, 1992.

conflicts between these instream uses. For example, flows necessary to support whitewater boating are higher than recommended maximums for brown trout habitat. Whitewater boating flows are also too high for fishing and for scenic boating. While fisheries can be sustained at some level, they cannot be maintained at optimum levels without harming other uses including bald eagles and whitewater and scenic boating.

The interagency group was unable to determine a single flow regime that would accommodate all uses. Within priorities given by the management plan, the group devised two instream flow scenarios (Figure 14.5). The comprehensive environmental scenario places a high value on resource protection, but largely excludes recreational boating flows. This scenario calls for a stable flow of 250 ft^3/s during the winter (October 15 to March 31) to support fisheries and bald eagle populations. This flow level also supports macroinvertebrates, scenic and aesthetic qualities and maintenance of riparian habitat. The scenario calls for a minimum flow of 185 ft^3/s during the remainder of the year to support riparian areas. This minimum flow level also largely meets the needs of brown trout and macroinvertebrates, maintains scenic and aesthetic qualities and supports recreational fishing. However, the flows do not meet the needs of either scenic or whitewater boaters.

The recreation-opportunities scenario calls for essentially the same flows as the environmental scenario for most of the year, but requires increased flows to provide better recreational opportunities from mid-July through August when recreational user demands are high. Under this scenario, flows would be increased to from 185 to 250 ft^3/s in mid-June to provide optimum fishing experiences and to 500 ft^3/s from July 15 to August 31 to accommodate scenic boating experiences. Peak flows of approximately 900 ft^3/s for whitewater boating would be provided on six weekends during this same time. The interagency group noted that no matter what scenario was chosen, increases in flow should be considered in hourly increments so that impacts to aquatic habitats are minimized. Instream flow hydrographs should approximate the natural hydrograph (high flows in the spring) to the extent that water is available.

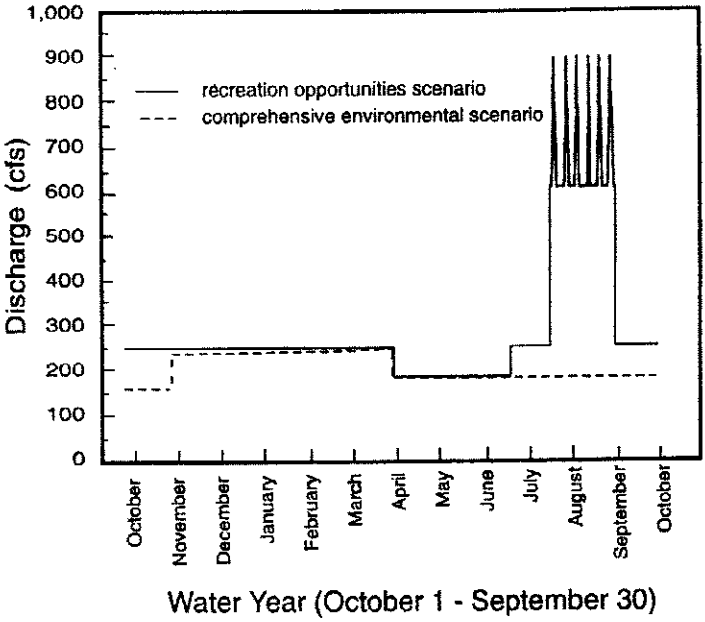

Figure 14.5 Alternative flow regimes for the Rio Chama emphasizing resource protection and recreation opportunities (from Fogg, J.L., Hanson, B.L., Mottl, H.T., Muller, D.P., Eaton, R.C. and Swanson, S., Rio Chama Instream Flow Assessment, USDI Bureau of Land Management, Denver, 1992).

Although the interagency group was unable to design a single instream flow regime that would optimize all instream uses and still meet downstream water-delivery obligations, the group was able to identify the flow-related needs of individual instream uses and to suggest scenarios that would accommodate as many uses as possible. The study was an example of successful interaction between scientists and policymakers; scientists and technicians provided important information about the choices and tradeoffs in allocating the water, but the actual choices were left to river managers, water users, courts, legislatures and the public. Instream flow quantification studies such as that at Rio Chama indicate that a high level of instream benefits can be provided in situations in which water is also used for offstream purposes. Tradeoffs between instream and out-of-stream uses exist, but the substantial overlap allows the two types of uses to coexist.

14.4 SUMMARY

Riparian areas of the Southwest represent scarce and precious resources that support a myriad of uses, not the least of which is outdoor recreation. Water is the life blood of riparian areas and the essential ingredient of riparian recreation. Whether it be boating, fishing, hiking, or simply viewing the landscape, the quality of the riparian recreational experience depends on the existence, and indeed the amount and timing, of available water. For each riparian recreation activity, the quality of the experience increases with flow level to a point, peaks and then decreases at ever higher flow levels. Each activity has its own minimum and optimum water flow levels. Therefore, different streams feature different sets of recreation activities and a given stream can feature different activities at different times of the year. Furthermore, recreation activities rely on riparian conditions that are maintained by still other sets of flows, such as occasional channel maintenance flows. Where flows are managed, options often exist for enhancing or at least protecting recreation opportunities for one or more activities. Because of the different needs of different activities, intricate flow regimes can be designed to assist a set of activities.

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