Controlled Flow Studies for Recreation: A Case Study on Oregon's North Umpqua River

Bo Shelby
Department of Forest Resources
Oregon State University
Corvallis, Oregon 97331 USA

Doug Whittaker [1]
Department of Natural Resources Recreation and Tourism
Colorado State University
Fort Collins, Colorado 80523 USA

Jerry Roppe
PacifiCorp
825 NE Multnomah, Suite 1500
Portland, Oregon 97232 USA

Abstract: The "controlled flow study" or "systematic field assessment" has received considerable attention as a quick, inexpensive, and useful approach to understanding relationships between streamflows and recreation. The approach is distinctive for control of the independent variable, flow, which adds a quasi-experimental component to study design. Many studies have used this approach in recent years, although there has been variation in the specific methods applied. A review suggests that there are five major issues involved in conducting these studies: study output, sample, flow control, impact on other resources, and study complexity. We present a controlled flow study of boating on Oregon's North Umpqua River, which provides examples of study output and reviews the technical challenges involved in conducting the study. Results suggest that the method can provide powerful information about the flow-recreation relationship, but that these studies can be relatively complex. Discussion focuses on ways to address these complexities and cautions researchers from assuming it is the best approach. Several possibilities for future research are also suggested.

Key Words: Bypassed reach, instream flow, relicensing, systematic field assessment.

INTRODUCTION

Streamflows for recreation are becoming an important topic on the river conservation agenda. Changes at federal land-managing agencies and extensive Federal Energy Regulatory Commission (FERC) relicensing activities have provided many new opportunities for assessing flow needs for recreation on dam-controlled rivers, and river recreation advocates have been increasingly interested in securing flows on those segments (Bowers 1998; Joseph 1998; Stewart 1998). Wise decisions about recreation flow releases require

1 Present address: P.O. Box 2036, Nome, Alaska 99762 USA.

reliable information about flow-recreation relationships. In addition, this information needs to be collected efficiently and in ways acceptable to the stakeholders involved.

Considerable work on flow and recreation has occurred in the past 10 years (Moore et al. 1990; Brown et al. 1991; Shelby et al. 1992a), and a variety of methods and concepts have been developed (see Whittaker et al. 1993 for a review). Discussions at workshops and national conferences show increasing consensus about the utility of various methods, although it is generally agreed that no one method is sufficient for all situations, and that multiple methods can improve the defensibility of information (Merrill and O'Laughlin 1993; Shelby et al.1997).

Within this general context, the controlled flow study or systematic field assessment has received a great deal of attention as a quick, inexpensive, and useful method, particularly for short segments just downstream of a dam (Giffen and Parkin 1993, unpublished report). The general idea is to release a variety of flows over a short period of time to allow scientists and stakeholders to evaluate them. The approach is distinctive for control of the independent variable, flow. This adds a quasi-experimental component to study design and allows systematic evaluations of recreation by several methods (e.g., surveys of recreation users, professional judgments, or hydraulic measurements for modeling purposes).

In this paper we examine the controlled flow approach and briefly review origins, recent applications, and technical issues. We also provide data from a controlled flow study on Oregon's North Umpqua River, which shows the types of information that these studies can provide. We then discuss problems and implications that need to be considered in conducting future controlled flow studies.

BACKGROUND

Method Origins and Recent Efforts

The earliest controlled flow study was conducted on the Snake River through Hell's Canyon on the Idaho/Oregon border (Bayha and Koski 1974). The study addressed the effects of flows on a variety of resources, including recreation (whitewater boating and jetboating), water quality, aquatic vegetation, fish, and wildlife. The project had many characteristics of future controlled flow studies: flow was controlled through dam releases, small teams of experts were transported to critical locations on the river to observe effects, and group discussion helped develop consensus about effects and evaluations of those effects. Unlike many recent efforts that focused on river segments less than 10 mi long, the Snake River study is notable for being conducted on a 68-mi segment where float trips typically take from 2 to 5 days. Because different flows were provided on successive days, study teams and their boats had to be transported by helicopters to run rapids; this was not a model for a quick and inexpensive study.

Perhaps because of logistic and financial costs, few studies have been patterned after the Snake River effort until adaptations were developed in the late 1980s and early 1990s as a result of FERC relicensing projects. (Most of these studies were conducted by consultants as part of the relicensing process and are generally available as contract reports only.) On these rivers, the most common focus was on boating or angling on short reaches directly below dams, often in by-passed reaches where flows had not been provided since the dams were built. In these cases, some researchers argued that the best way to explore flow-recreation relationships was to experimentally control flows and evaluate effects on recreational activities. This seemingly simple assertion, however, conceals many potential complexities.

Two different models were followed in conducting these FERC studies. One model mimicked the Snake River effort and used teams of researchers to evaluate boating or angling conditions as flows changed. Prominent studies of this type included those on California's American River (Watson 1985, unpublished report) and Oregon's McKenzie River (EA Engineering 1991, unpublished report). The strength of these studies was in the systematic control of flows and the quality of observations by team members. However, the studies generally did not provide quantitative information about conditions or flow evaluations, or include user input.

The second model utilized recreational users to help evaluate boating or angling conditions as flows changed. Many of these studies were conducted by Giffen and Parkin, the method's strongest proponents. Their first study (1993, unpublished report), conducted on the east outlet of Moosehead Lake at the headwaters of the Kennebec River in Maine, evaluated boating and angling conditions at six different flows. Small teams of researchers and users completed evaluations. A key component of their effort was focus group discussion at the end of each observed flow and at the end of the study. These discussions helped to build consensus about flow effects and final evaluations, which formed the basis for flow requests by the boating community in the FERC process. This study appears to have worked well because recreational opportunities were well defined, users interested in them were homogenous and generally well organized, and consensus results were easily and credibly inserted into the flow negotiation process (Giffen and Parkin 1993, unpublished report).

From a scientific standpoint, however, some of these studies are limited because they yield little quantifiable information, or because user participation was low and arguably suspect. More recent efforts have attempted to address these problems through the use of survey methods or more participants. Example studies include those on Connecticut's Farmington River (Land and Water Associates 1992, unpublished report); Georgia's Tallulah Gorge (EDAW 1993, unpublished report); California's Pit River (Watson 1996, unpublished report) and the Lower Saluda River through Columbia, South Carolina (Sparling 1997, unpublished report). Although these later studies were more rigorous and provided more defensible information, most have not been published in peer-reviewed journals.

Issues in Conducting Controlled Flow Studies for Recreation

A review of the full range of technical issues involved in each of these studies is beyond the scope of this paper. However, familiarity with these and other studies suggests at least five major issues that researchers need to consider when designing controlled flow projects.

Study Output. Decisions about evaluative information are crucial for determining the level of detail and whether data will be qualitative, quantitative, or both. Studies using focus groups to develop evaluations rely more on consensus decision making and less on quantitative data. Although this approach is easier and costs less, it lacks rigor, even with carefully developed evaluation criteria. Focus groups provide excellent opportunities for generating new ideas and airing differences of opinion, but they are also susceptible to group dynamics, which may affect conclusions.

With increased quantitative efforts—usually involving participant surveys—the level of detail can be greater, but there are still choices about the level of detail required. For example, should participants only rate the flow on an overall scale, or should they also rate more specific components of the flow-quality relationship (such as boatability, whitewater, or aesthetics)? Should evaluations be treated as a single group, or should they be broken out by factors such as craft and skill level differences? Controlled flow studies offer opportunities to collect considerable amounts of quantitative information from participants, but such studies are more complex and more expensive. For example, a greater burden is placed on individual participants, and more detailed analyses of subgroups (such as those with different skills or craft types) may require larger numbers of participants.

Flow Control. The fundamental characteristic of a controlled flow study is experimental manipulation of flows at distinct and informative levels. Ideally, researchers seek to evaluate the full range of flows that could be expected to occur, with appropriate increments in between (Giffen and Parkin 1993, unpublished report). In practice, however, there may be political, administrative, legal, financial, liability, or technical constraints in determining which flows can or will be provided.

The largest obstacles tend to be administrative, political, and legal; many dams have operation guidelines or water rights obligations that are difficult to amend, even for short study periods of a day or two. Direction from the FERC and pressure from advocacy groups may convince operators to provide some releases for studies, but our experience suggests that this is difficult to achieve. Controlled flow studies often involve releases that are distinctly different from the status quo, and powerful interests often protect the current regime. Securing more than a few flows is usually difficult, and, in some cases, it may not be possible to secure any.

An example of this occurred in the Grand Canyon, Arizona, where a variety of instream flow studies were conducted in the 1980s as part of a review of Glen Canyon Dam operation (Shelby et al. 1992b). Early in the effort, proposals for controlled flows were seriously considered as an appropriate way to explore effects on rapids and other recreation features. When the potential costs of providing those flows for the required periods were calculated, however, it became clear that these releases would be unavailable.

Even when dam operators are willing to provide the flows for a study, there may be surprising engineering or hydrological constraints in terms of what they can provide and when. Dams are not always designed to release precise increments of water, and close cooperation with the on-site manager of the dam is crucial to determine what flows are possible. Because inputs from tributaries or rainfall can further affect the flows that are actually evaluated in a study, researchers need to understand these variables when requesting releases. Also, there is a time lag between flow releases from the dam and a stabilized flow in the channel below, which may decrease the number of flows that can be seen in a given time period. Similarly, on a river with a small storage capacity behind the dam, certain releases may drain the reservoir enough so that subsequent releases cannot be provided.

It may be difficult to estimate which flows should be examined, as well as to determine the safety and liability issues involved. For a recent study on a steep bypassed reach on California's Hat Creek, for example, it was hard to know what flows to provide because no one had ever boated the segment. In addition, trees and other vegetation had filled the channel since the time of diversion, adding to the potential risks. A limited range of three flows was proposed for release. When the first (medium) flow was provided, a boating test showed that recreational boating was not feasible at that or any other flow, and it was unnecessary to look at other flows during the study (B. Shelby 1997, unpublished report).

Sample. The people who evaluate flows are an important component of a controlled flow study; choosing between a team of researchers or including recreation users is critical. Similarly, there are choices regarding the number and make-up of participants (e.g., commercial versus private users, users with different skill levels or types of craft, or including representatives of conservation groups, advocacy groups, or agencies). In addition, although larger sample sizes produce more quantitative information, there are trade-offs in terms of costs and logistics when more participants are involved. It also is important to identify various users' interests and their potential biases ahead of time to ensure that information is collected in ways that reduce bias or allow analysis of differences. For example, a study on Connecticut's Farmington River (Land and Water Associates 1992, unpublished report) included local users and others from outside the area to prevent strategic efforts by conflicting user groups. Finally, there is the challenge of retaining the panel of evaluators throughout the course of a study. It may be difficult to keep the same individuals for studies that require several days, or are conducted periodically throughout a long season.

Impact on Other Resources. Controlled flow studies involving releases different from the status quo may affect other resources along a river segment (Schmidt et al. 1998) and further complicate release requests. Common concerns include fish stranding as flows "ramp down," or fish being flushed downstream by higher than usual flows. Releases outside the normal flow range may also affect bank erosion, use of downstream facilities, or liability.

Time, Money, and Logistical Complexity. Finally, the quality and utility of controlled flow studies are related to the resources that are available. Giffen and Parkin (1993, unpublished report) have suggested that the approach is inexpensive and efficient, but this depends on the depth and breadth of the study. Decisions about the number of flows to assess, the number of participants, and the types of information to be collected will have substantial impacts on project costs and complexity.

CASE STUDY METHODS

Study Area

The North Umpqua River in southwestern Oregon is known for its whitewater boating and angling opportunities. This paper focuses on boating on the 16-mi segment from Soda Springs Powerhouse to Gravel Bin, which is used by both private and commercial river runners.

Boating opportunities on the North Umpqua feature day trips through a scenic, semi-primitive environment (a road follows the river for the entire reach). Most boaters use small to medium-sized rafts (12- to 16-ft long) or hard-shell whitewater kayaks. A few boaters use catarafts or inflatable kayaks. Almost all users take day trips, although a few camp at developed campgrounds along the river. Trips usually take from 6 to 7 hours.

"Standard" whitewater trips on the North Umpqua are defined by a variety of Class II and III rapids throughout the run, as well as one Class IV rapid. The river features a mix of large hydraulics (most of which will not flip rafts), standing waves (most rafters expect to be wet throughout the day), powerful chutes through boulders, and frequent "playspots" for kayakers to surf or practice other moves. Although boaters need the skills to negotiate Class III rapids, most boating errors have relatively minor consequences because the rapids end in pools and an access road is nearby. Through the majority of the peak boating season (May through August), the air temperature is also, forgiving even if the water temperature is not.

At higher flows, there is an alternative to "standard" trips. Because these "high challenge" whitewater trips feature larger waves and more powerful hydraulics that can flip rafts, the difficulty of negotiating many rapids increases. Such "challenge" opportunities are typically available only during the rainy season from October to April.

The Controlled Flow Study

The study evaluated nine controlled flow levels ranging from 590 cfs to 3,000 cfs. This was the relevant flow range given current dam operation and potential water development options. The 590 cfs flow was assessed during a pilot study conducted in September 1992. The remaining flows were assessed from May to July 1993.

The panel included individuals from federal, state, and county agencies (U. S. Forest Service, U. S. Bureau of Land Management, U. S. National Park Service, Oregon State Parks, Douglas County); private entities (PacificCorp and its consultant, EDAW); professionals taking an instream flow and recreation short course; interested private users; and commercial outfitters. Boaters ran the river in rowing rafts, paddle rafts, and kayaks. In total, 73 individuals participated in the boating assessment, but not all ran the river at all nine flows.

For the study, the river was divided into three reaches based on access points and common- use patterns. As boaters completed each reach, they filled out a survey. At the end of the day, boaters also completed a short survey about the entire river and attended a focus group meeting. (A first version of the survey was pilot tested at the 590 cfs flow in 1992 and then revised for subsequent assessments in 1993. Because some questions were asked differently, they cannot be compared for all nine flows.) At the meetings, discussion was organized to provide more detailed qualitative information about conditions at that flow, adding depth to the quantitative information from the surveys. Finally, 24 boaters completed a "close-out" survey at the end of the study where they were asked to rate the full range of flows.

Respondents were asked to evaluate flows with regard to various conditions (boatability, whitewater challenge and safety, rate of travel, and aesthetics) as well as to provide an overall evaluation. Other questions asked boaters to rate the skill level needed to boat the segment and flow; to report how many times they had various boatability problems and their tolerance levels for those problems; and to check (from lists provided) the top three advantages and disadvantages of each flow. Examples of advantages included: "lots of power in the water," "good rate of travel," and "a good flow for learning." Examples of disadvantages included: "waves were too large," "too many rocks," and "not enough challenge."

For the purposes of this paper, overall evaluations were the most useful type of information. Boaters were asked evaluate the overall acceptability of flows for their skill level and type of craft, giving consideration to all of the conditions that make up a high quality trip, including boatability, whitewater challenge, safety, rate of travel, and aesthetics. Responses were on a on a five point "acceptability" scale ranging from "totally unacceptable" to "totally acceptable," with a mid-point labeled as "marginal." For the "close-out" survey, users rated all the flows they had seen on a seven point "acceptability" scale.

RESULTS AND FINDINGS

Evaluation results are presented in graphic form. The horizontal or x-axis reports the various flows; the vertical or y-axis represents the acceptability scale. For each flow observed during the assessment, a mean or average acceptability rating among participants has been calculated and plotted. When the mean ratings for all flows are connected, they describe a flow evaluation curve (Shelby et al. 1992b).

Overall Acceptability Curves for Boating

Two overall acceptability curves for boaters are given in Figure 1. The first curve (marked by triangles) shows ratings made by boaters at the end of the day when a specific flow was experienced. The second curve (marked by squares) shows ratings from the close-out survey at the end of the study.

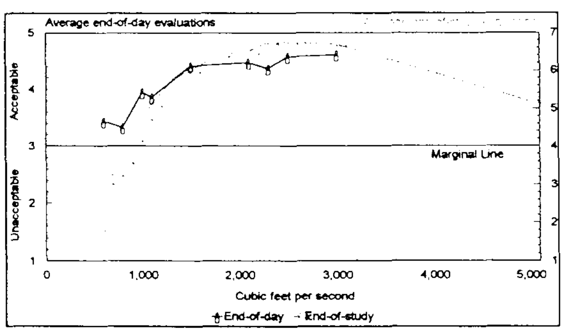

FIGURE 1. *Overall acceptability curves for boating based on average ratings from the end-of-day and end-of-study surveys.*

Results suggest at least three major findings. First, both curves show that flows in the 1,500 to 3,000 cfs range receive the highest ratings, thus defining an "optimal" range. Because the evaluations do not decrease at 3,000 cfs (the highest flow provided under the engineering constraints of the project), the shape of the curve suggests that the optimal range might extend to higher flows.

Second, end-of-the-day ratings show that all of the flows in the range between 590 cfs and 3,000 cfs provide at least minimally "acceptable" boating opportunities, while the close-out survey results indicate that flows below 1,000 cfs are marginal and flows below 600 cfs are unacceptable. Differences in these results may reflect some significant methods issues (discussed below).

Third, the end-of-the-day acceptability curve is not as smooth as the end-of-the-study curve, with counter-intuitive dips in the curves at 800 cfs, 1,100 cfs, and 2,300 cfs. This is probably related to assessments that were conducted on nonconsecutive days; the nine flows were assessed during five different study periods (three flows were assessed singly, while on two other occasions participants assessed three flows on three consecutive days). The dips in the curves occurred when a single flow or a new series of flows were assessed.

There are at least two methodological issues that may have created the dips in the curves. It is possible that boaters rated the last of each series of flows too low in comparison with two previous flows that were clearly better. This would account for the lower rating of flows at 2,300 cfs and 1,100 cfs. It is also possible that the single flow assessments (or the first in a series of three) were rated too high. All nine flows were assessed on good weather days. For most participants, the opportunity to be outdoors and conduct assessments offered a distinct contrast from their usual office work, which raises the question of whether the participants' evaluations on the first day were influenced by the good weather and the prospect of a day on the river. If so, this would account for the higher rating of flows at 590 cfs, 1,100 cfs, and 2,000 cfs.

A related methodological issue concerns the ability of participants to make evaluations without much basis for comparison. For example, the 590 cfs flow was assessed in the pilot study 7 months before any of the others. Similarly, the 1,000 cfs flow was observed by a panel that included participants from an instream flow short course. In both cases, the majority of participants had not seen the river at any other flow and, thus, had less basis for making comparisons. In retrospect, it appears that both the 590 cfs and 1,000 cfs ratings were higher than they would have been if they had been assessed with the other flows; this hypothesis is further corroborated by results from the end-of-study survey, in which the panel rated these flows distinctly lower.

Relationships between Boatability Conditions and Flows

In addition to evaluations, objective measures of particular boatability conditions were reported by participants during the study. Figure 2 shows the average number of "hits" (when the boat hits a rock but is not stopped) and "stops" (when the boat is stopped and requires pushing off). These generally decline at higher flows, with the notable exception of the higher number of hits at 800 cfs compared with those at 590 cfs. This result may reflect differences in the samples (the 590 cfs boaters may have been more skilled), but could also be a function of increased power in the river at 800 cfs. This latter notion is supported by focus group discussion and high levels of reported hits on the third segment (segment data not shown), which has the more difficult rapids. At a flow of 590 cfs there were more exposed rocks; however, a boater with more patience and skill could maneuver around them. At the 800 cfs flow there were fewer exposed rocks, but, because there was more power in the river, boaters were pushed into these rocks more often.

Participants were also asked to specify their tolerances for hits and stops. Results show that 74% will tolerate no more than 30 hits per day, and 80% will tolerate no more than 3 stops. Among boaters with advanced skills, these tolerances are even more stringent (a majority would not tolerate more than 20 hits or even a single stop). Applying these standards to the data in Figure 2 suggests that flows below 1,000 cfs create more boatability problems than boaters will tolerate, while flows above 1,500 cfs do not exceed these tolerances.

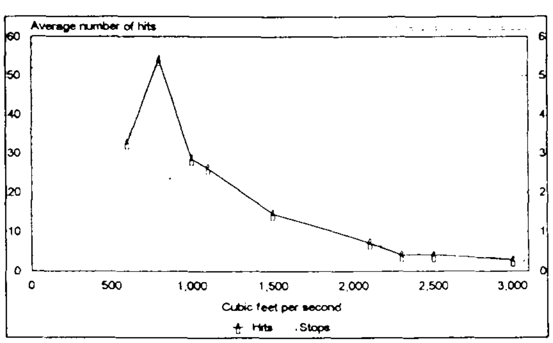

FIGURE 2. *Relationship between flow levels and the average reported number of "hits" (when the boat hits a rock but is not stopped) and "stops" (when the boat is stopped and requires pushing off.*

Advantages and Disadvantages of Flows for Boating

Boaters were asked to check (from a provided list) the top three advantages and disadvantages of each flow. Figure 3 shows advantages and disadvantages for three different flows throughout the range and highlights the qualitative differences between them.

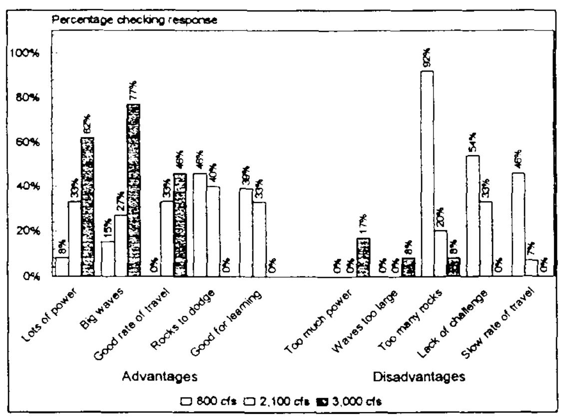

FIGURE 3. *Examples of advantages and disadvantages of three distinct flow levels (800 cfs, 2,100 cfs, and 3,000 cfs).*

A large percentage of respondents rated "large waves" and "power in the river" as advantages of the 3,000 cfs flow. Boaters also thought that the two higher flows provided a "good rate of travel." These results agree with information collected at focus group meetings, which characterized the highest flows as more "challenging," but not "too challenging." (Only 17% reported "too much power" as a disadvantage and only 5% reported that "waves were too large.")

In contrast, boaters reported that the lower flow (800 cfs) was "good for learning" and that it presented "many rocks to dodge." In focus groups, this was commonly characterized as a more "technical" trip. Whereas almost half of the respondents listed "rockdodging" as an advantage of the trip, nearly all (92%) noted that "too many rocks" were also a disadvantage of this flow. About half of the respondents also reported that the "lack of challenge" (54%) and a "slow rate of travel" (46%) were disadvantages of the 800 cfs flow. Taken together, the results suggest that flows of 800 cfs have some noticeable deficiencies that are recognized by most boaters, which helps explain the lower overall acceptability ratings of that flow.

DISCUSSION

It has often been assumed that a "controlled flow" study is the best method for assessing the effects of streamflows on recreation (Giffen and Parkin, 1993, unpublished report). The basic premise seems obvious: vary the flows and evaluate the impact on the recreational experience. But as with many "obvious" premises, there are several potential pitfalls. All five controlled flow study issues (described at the beginning of this paper) were relevant to the research conducted on the North Umpqua. A brief review of those issues and how they were addressed in this study has implications for future research.

Study Output

We have provided examples of the wide variety of detailed quantitative and qualitative information collected during the North Umpqua study. In addition to the kinds of survey information, the study also produced survey information for angling, results of focus group discussions, and a videotape of boaters and anglers using the river at key locations. Taken together, these data provided the basis to make definitive judgments about acceptable and optimal ranges of flows for various activities— important information that was later used during the FERC relicensing process. Controlled flow studies that are less detailed or quantitative may also provide useful information, but we believe that as streamflow decisions become more complicated and controversial, greater rigor will be required. As illustrated here, controlled flow studies have the potential to provide that rigor.

This point is particularly relevant for some of the results from this study. For example, addressing the counter-intuitive dips in overall ratings from the end-of-day survey was easier because end-of-study data revisited overall evaluations. Similarly, the "acceptable" ratings of the initial 590 cfs flow assessment could be revisited through the end-of-study survey results, which showed that the 590 cfs flow paled in comparison with higher flows observed later. With multiple types of information, researchers had the data to discuss and resolve these differences.

Flow Control

Originally conceived as a 5-day / 5-flow study, several factors combined to make flow control on the North Umpqua more difficult than anticipated. Eventually, the study was extended into a two-season effort with several nonconsecutive data collection periods. The major factor was a small storage capacity behind the dam. There simply was not enough water in the reservoir to provide the full range of flows over the course of a week, even if the utility company had been willing to empty it (which they were not, for a variety of biological and political reasons). The reservoir was also unable to "hold back" unexpected high flows. To conduct the study through a full range of flows we had to capitalize on variation in the natural flow regime, but this was difficult. Schedules were revised throughout the study to capture flows distinct from those observed previously. A full range of flows was ultimately assessed, but it took considerably more time and effort than anticipated.

Finally, even when certain flows appeared to be arranged, engineering constraints and tributary inputs sometimes altered the flows observed during the assessments. Dam operators were unable to control flows down to the nearest 100 cfs, and, on two occasions, flows were different from those expected. Taken together, these challenges in controlling the flow had many important impacts on the study.

Sample

Maintaining a consistent panel across the nine flow assessments was a major goal of the study. Recognizing that the North Umpqua was a popular but relatively remote resource, the utility sponsoring the study offered per diem expenses and lodging as an inducement. Even so, because the study took place on several weekdays over several months, some participants could not attend every assessment. Although recreationists appear willing to volunteer their time to help with studies like this, most volunteers have time constraints, and nine full days of boating the same river segment is a significant commitment. Studies on shorter river segments where multiple runs per day are possible do not face this kind of problem.

Ensuring diversity in the assessment panel also was an important goal of the study. It was challenging to achieve a cross section of agency staff, local users, commercial guides, and outside experts as well as boaters with a variety of skill levels and craft types. It is obviously easier to use researchers to evaluate flow effects, but we think including a range of "stakeholders" improves both scientific quality and political support.

A key to addressing sampling issues was the quantification of study output, which allows comparisons of conclusions from "core" participants (who observed most of the flows), other participants, and people with various skill levels and craft types. Although beyond the scope of this paper, the wealth of data allowed us to explain differences between groups such as rafters versus kayakers, or boaters with more versus less river running experience.

Impact on Other Resources

Because the North Umpqua has an internationally-acclaimed wild steelhead run, the controlled flow study required sensitivity about possible effects on biological resources. Concerns about the effects on fish in fall 1992 actually limited that year's work to a single flow (the existing one), even though requested releases were well within the dam's operating guidelines. The lesson in this is to ensure that all stakeholders endorse a proposed study before starting. A year later many of these issues had been resolved, primarily because the study was designed to capitalize on natural variation in flows, and companion studies of fish stranding were also conducted.

Time, Money, and Logistical Complexity

The North Umpqua controlled flow study was complex, and its success was due in large measure to the commitment of the utility company and associated agencies to the project. Giffen and Parkin (1993, unpublished report) have noted that the approach is most appropriate when time and financial resources are at a premium, but there is obviously a significant range in the costs of such studies. Examining three flows on a 5-mile bypassed reach with easy road access may only take a day and could be relatively inexpensive, especially if one uses a small study team and adopts a qualitative approach. On the longer North Umpqua, each assessment took a full day, there were more participants traveling to a remote resource, and considerable effort was expended in collecting a variety of qualitative and quantitative data on a relatively large number of flows. The lesson is that, as with other types of research, increasing complexity (by adding flows and participants) may increase costs.

CONCLUSION

Results from this study suggest that controlled flow studies can be powerful determinants in establishing relationships between streamflows and recreational quality. We also suggest that such studies may be relatively complex, requiring careful consideration of study output, flow control, sampling, impacts on other resources, and cost/complexity.

These conclusions have some important implications for managers and researchers. In situations where river segments are short (less than 5 mi), flows can be definitively controlled, the river is easily accessible, and users are readily available, we believe that a controlled flow study provides unquestionable utility. However, in situations without these characteristics, researchers should not assume that it is the best approach. It is easy to underestimate the complexity of controlled flow studies, and addressing the necessary issues may be more expensive and less defensible than methods that do not require such an extensive field experiment.

Findings from the North Umpqua controlled flow study also highlight several research issues that deserve attention in future studies. First, ratings may be subject to "order effects." For instance, will ratings differ if participants observe low flows before high flows, rather than the other way around? Second, there may "timing effects." For example, will ratings change if flows are observed during one short period rather than periodically throughout a season? Third, group dynamics may affect ratings in controlled flow studies because participants run rivers as a group and spend considerable time together; future studies might address this issue by organizing participants into independent groups and comparing results.

Finally, there may be opportunities to compare controlled flow results with those from other approaches on the same river. For example, do "flow comparison surveys" of guides and experienced river users provide the same results as controlled flow studies? Use of both methods would allow discussion of the tradeoffs between controlled flow studies (which add precision by controlling the independent variable, flow) and survey studies (which depend on participant knowledge and recall of past experiences).

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