

Impact of Research and Technical Change in Wildland Recreation: Evaluation Issues and Approaches

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Abstract *The development and diffusion of new technologies have had tremendous impacts on wildland recreation in recent decades. This article examines the potential economic impacts of research and technical change in wildland recreation. Two evaluation models are presented, a cost-price approach and a research intensity model, which are intended to shed some light on the question of whether society has over- or underinvested in recreation research. These two evaluation models are applied to the case of recreation on the U.S. National Forest system. The cost-price analysis indicates that the economic benefits of past U.S. Forest Service recreation research would only need to be extremely small—about 3¢ per recreation visitor day in present value terms—to justify past research expenditures in economic terms. The research intensity analysis revealed that the intensity of Forest Service recreation research is about 20 times less than all Forest Service research, suggesting a possible underinvestment in recreation research.*

Keywords wildland recreation, research, technical change, evaluation, economic impacts.

A number of studies have examined the economic impacts of new technologies generated by forestry and forest products research (Hyde, Newman, & Seldon, 1992; Jakes & Risbrudt, 1988). These evaluations compare the economic costs and benefits of a given research effort to determine whether the research has been a worthwhile investment from an economic perspective. The economic payoff (as measured by rates of return and cost-benefit ratios) from investment in forestry research has generally been quite favorable, comparable to returns from investment in agricultural and industrial research.

Past forestry research evaluations have focused mainly on forest products research,

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however, and neglected "noncommodity" areas such as wildland recreation research. Researchers seldom think about the extent to which research and resulting technical change have affected wildland recreation. This is understandable given the nature of this activity: Wildland recreation occurs in largely natural settings, managers strive to maintain a natural appearance, and the development of facilities is limited (Hammit & Cole, 1987). However, the development and diffusion of new technologies have had tremendous direct and indirect impacts on wildland recreation in recent decades. For example,

- New recreation activities and markets have been created (e.g., snowmobiling, mountain biking, and hang gliding).
- New recreation activities have increased conflict between competing user groups (e.g., snowmobilers vs. cross-country skiers, power boaters vs. floaters, and off-road vehicle drivers vs. hikers).
- Recreational equipment quality and diversity have improved.
- New recreation management technology has influenced the cost of providing recreational opportunities and the perceived quality of recreation experiences.
- Techniques for managing visitors have helped ameliorate the environmental impacts of recreation activities.
- Technology for managing other forest resources has affected recreation resources, values, and uses (e.g., even-aged management of timber resources).
- Technologies developed in other sectors of the economy have had significant indirect impacts on recreation (e.g., advances in transportation technologies have increased access to recreation sites).

These examples illustrate that the impacts of technical change on wildland recreation have been diverse and substantial. New recreation resources can be "created" or existing resources extended through technical change. Cordell (1988) provided the following example: "New technology and equipment, such as hang gliders, help make different kinds of recreation possible—they help create new supply. The development of hang gliders caused land managers to pay more attention to cliffs with updrafts; these are now recreational environments" (p. III-3). In addition to increasing supply, technical change can also expand the demand for recreation by increasing the quality of recreation experiences. Therefore, long-range forecasts of the supply of and demand for wildland recreation that do not take into account the effects of technical change will not be accurate.

More narrowly, technologies produced by public sector recreation research have also had significant impacts, despite the fact that such research was almost nonexistent before 1960 (Lucas, 1987). For the case of wilderness, it has been argued that "the foremost success stories in wilderness management—programs for wilderness fire, use limitation, visitor education, campsite management and development of the limits of acceptable change process—have all been based on a substantial foundation of research" (Cole, 1990, p. 19).

Several previous studies have examined certain aspects of technical change related to wildland recreation. Valfer et al. (1987) reported on the challenges that new technology presents for managing recreation on the National Forests and suggested strategies to deal with these challenges. Shafer, Moeller, and Getty (1974) used the Delphi technique to explore future leisure environments, including technology related to wildland recreation management. Shafer (1989) and Shafer and Moeller (1988) identified potential technological developments that may affect tourism and recreation in the future. D.H. Anderson and Schneider (1993) surveyed U.S. Forest Service recreation managers and researchers to identify the most significant recreation management innovations and perceptions of their contributions to management goals. Others have discussed the general importance of

technical change in recreation (e.g., Clawson, 1985; Cordell, 1990; H. C. Davis, 1970). Given the economic importance of wildland recreation, the likely magnitude of past impacts of technical change in this sector, and the prospects for future impacts, it is surprising that so little analysis of this area has been carried out. Recreation is indeed a neglected sector in the study of technical change and evaluation of research impacts.

This study examines some conceptual issues related to evaluating the economic impacts of research and technical change in wildland recreation and proposes two possible evaluation frameworks. The next section examines the potential economic impacts of technical change in wildland recreation, including a taxonomy of recreation technology, a discussion of how new management technologies affect the production processes related to recreation, an idealized conceptual framework for analyzing the economic impacts of new recreation management technologies, and some examples of significant recreation management innovations identified by recreation managers. The section following that presents two evaluation models that are intended, in the absence of hard data about the economic benefits of recreation management technologies, to shed some light on the question of whether society has over- or underinvested in recreation research. These two evaluation methods are applied to the case of recreation on the National Forest system. In fiscal year 1991, visitors spent 279 million recreation visitor days (RVDs) on National Forests, about 40% of all recreation provided by federal agencies and more than any other federal agency in the United States.

Economic Impacts of Recreation Research: Conceptual Issues

A Taxonomy of Recreation Technologies

Before we discuss the economic impacts of recreation technology, we need to clearly identify the types of recreation technology that are the focus of this study. A taxonomy of recreation technologies follows:

- I. Recreation management technology (introduced and controlled by recreation managers)
 - A. Visitor management technology (used to modify visitor behavior), for example,
 1. Systems for rationing use such as fixed itinerary systems
 2. Dispersal systems
 3. Communication technology (to inform and educate recreationists)
 - B. Site management technology (used to restore, maintain, or improve conditions or infrastructure at the recreation site), for example,
 1. Site hardening techniques
 2. Construction and maintenance technology
 3. Vandal resistant facility designs
 - C. General management technology (used to plan and manage recreation resources and services), for example,
 1. Planning systems
 2. Administrative systems
 3. Information networks.
- II. Recreation consumer technology (introduced and controlled by recreationists)
 - A. Recreation equipment technology (modifies existing recreation activities), for example,
 1. Lightweight camping equipment
 2. New fabrics for outdoor clothing
 3. Freeze-dried foods

- B. New activity technology (creates a new recreation activity), for example,
1. Off-road vehicles
 2. Mountain bikes
 3. Snowmobiles

Two basic types of technology are distinguished, recreation management technology and recreation consumer technology. Recreation management technologies are introduced and controlled by recreation managers and include visitor management technologies (used to modify the behavior of recreationists), site management technologies (used to restore, maintain, or improve conditions or infrastructure at the recreation site), and general management technologies (used to plan and manage recreation resources and services). Recreation consumer technologies are introduced and largely controlled by recreationists and include recreation equipment technologies (which modify existing recreation activities) and new activity technologies (which create new recreation activities).

This article focuses on recreation management technologies, most of which are produced by public sector recreation research. This is not to deny the significant economic impacts of recreation consumer technologies. Some would argue that consumer technologies have had greater impacts than management technologies; this is certainly true in risk recreation, where new consumer technologies have been a driving force (Ewert & Schreyer, 1990). Clawson (1985) has commented on the significant impacts of new consumer technologies on wildland recreation activities as follows:

Another development of the past 25 years . . . has been the development of new technologies and new equipment in outdoor recreation . . . the camper trailers, tents and other camping equipment, hunting and fishing equipment, and many other tools for outdoor recreation have improved greatly in quality, have provided more diverse models and types, and sometimes at lower real prices. (Clawson, 1985, pp. 79–80)

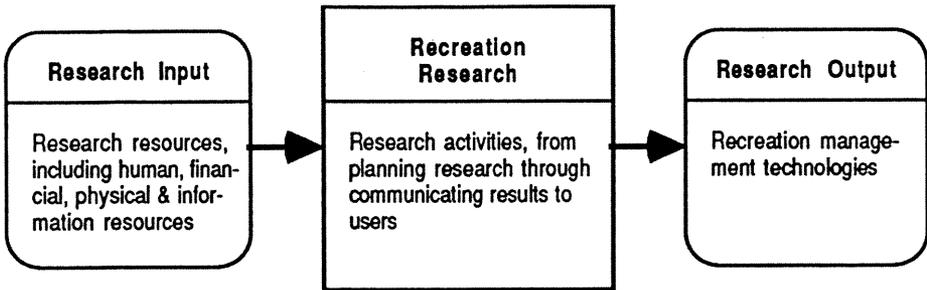
Three Production Processes

Evaluating the economic impacts of recreation research and the recreation management technologies produced by research requires a consideration of three interrelated production processes (see Figure 1). The first stage is the recreation research process, which requires inputs of research personnel, funds, information, facilities, and equipment. Recreation management technologies and new knowledge about recreation are produced as outputs of this process.

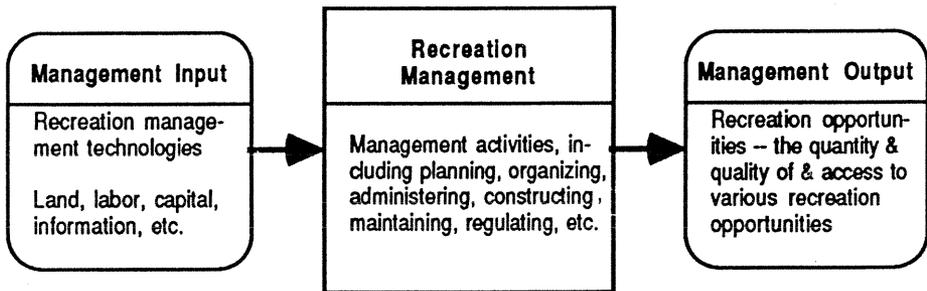
Research is not the only source of new technologies in recreation.¹ Another important source is “informal” research and development, defined as small-scale knowledge-gaining or problem-solving activities carried out by nonscientists outside of formal research organizations or departments. Recreation managers produce many incremental recreation innovations that cumulatively have significant economic and other effects. Knopp (1977) gives several examples of recreation research conducted outside of research organizations. Technologies imported from other sectors of the economy—or interindustry technology flows—are another important source, although these are usually equipment and new activity technologies. For example, innovations in recreational equipment such as syn-

¹See Bengston and Gregersen (1992) for a discussion of the sources of new technologies in forestry.

Recreation Research Production Process



Recreation Management Production Process



Recreation Experience Production Process

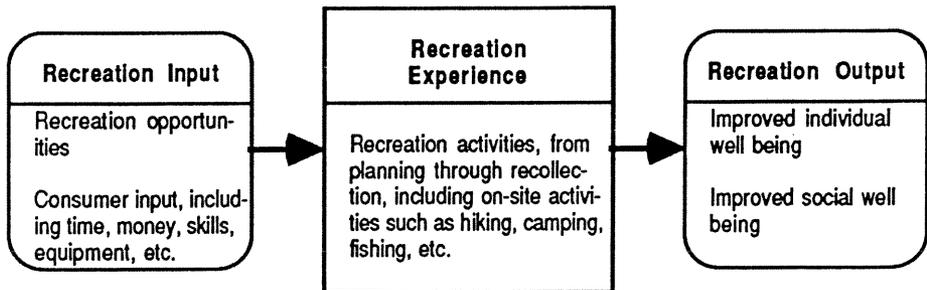


Figure 1. Three interrelated recreation production processes. Adapted from “Benefits of Outdoor Recreation and Some Ideas for Valuing Recreation Opportunities” by P.J. Brown in G.L. Peterson and A. Randall (Eds.), *Valuation of Wildland Resource Benefits* (p. 212), 1984, Boulder, CO: Westview Press. Also adapted from “Managing for Changing Recreation Needs on National Forests—A Viewpoint” by G. R. Super and H. K. Cordell in J. T. O’Leary, D. Fessenmaier, T. Brown, D. Stynes, and B. Driver (Eds.), *Proceedings of the National Outdoor Recreation Trends Symposium III* (Vol. 2, p. 816) 1990, Indianapolis, IN: Leisure Research Institute, Indiana University.

thetic fabrics and lightweight materials for camping gear and canoes have originated outside of the recreation sector. Cordell (1990) noted that

a large part of technological advancement has come from military and other nonrecreation sources. From military technology has come four-wheel drive vehicles, rubber rafts, and the parachute. Much of the outdoor clothing and camping equipment have also come from military research. More recently, space technology has provided the lightweight "space blanket." (Cordell, 1990, p. 260).

Some recreation management technology is adapted from external sources, such as visitor dispersal models based on engineering traffic models (e.g., Peterson, de Bettencourt, & Wang, 1977) and operations research.

The second production process shown in Figure 1 is recreation management, which includes activities such as planning, organizing, and administering programs; constructing and maintaining facilities; and so on. Inputs to this production process include recreation management technologies produced by recreation research and other management inputs such as land, labor, capital, and information. *Land* is defined broadly as the natural endowment and includes natural areas, water bodies, climate, plants and wildlife, and unique scenic character. *Information* is also a diverse and vital set of inputs into recreation management and includes information about economic, social, and cultural changes that influence the demand for various types of recreation, information about alternative sources of supply for different types of recreation, and so on. Recreation management can be viewed as a production process that transforms these inputs into outputs. The outputs are the quantity and quality of and access to various recreation opportunities and protection and enhancement of the natural environment.

The final production process is the production of recreation experiences by consumers (recreationists) themselves. In this process, recreationists combine inputs such as time, money, skills, and equipment with recreation opportunities and engage in specific recreation activities. The outputs of this final production process are the direct impacts that recreation experiences have on recreationists (increased individual well-being) and the indirect impacts of recreation activities on society (increased social well-being). Increased individual well-being as a result of participation in recreation activities is due to benefits such as increased physical and mental health, knowledge, self-esteem, and so forth. Increased social well-being results from increased jobs and income, a more healthy and knowledgeable population, and so forth (Brown, 1984; Driver, Brown, & Peterson, 1992).

For clarity of exposition, Figure 1 does not show the many feedback loops that connect these three interrelated production processes. For example, recreation activities have various environmental impacts (e.g., on soil, vegetation, wildlife, and water), and therefore affect the bundle of recreation management inputs referred to as land. Other feedback loops that link the three production processes include feedback from recreationists to recreation managers on the quality of recreation experiences and the demand for recreation opportunities, feedback from recreation managers to researchers on the usefulness of recreation management technologies and the need for new technologies, and so on.

Recreation Research Benefits: A Conceptual Framework

A variety of direct and indirect benefits may result from the adoption of new technologies produced by recreation research. These benefits parallel the benefits of recreation activ-

ities and management in general, as most technological innovations in recreation enhance existing benefits from these activities.² Recreation researchers have studied recreation benefits and values extensively. For example, Brown (1984) and Driver et al. (1992) classified the benefits of outdoor recreation and leisure into five categories: economic, social, cultural, physiological, and psychological. On the basis of a review of the recreation research literature, Driver, Nash, and Haas (1987) developed an exhaustive taxonomy of recreation and wilderness benefits that is classified by whom the benefits accrue to: individuals, society, or nonhuman organisms (see Table 1). The broad scope of recreation benefits listed in Table 1 hints at the rich body of work by social scientists examining the value of recreation activities.

In economics, the value of recreation and the value of the incremental benefits due to new recreation technologies are defined much more narrowly. Economic value has been correctly characterized as "a species of the genus value" (B. M. Anderson, 1966/1911, p. 93). We distinguish two types of economic benefits attributable to the adoption of recreation management technologies: (a) those due to decreased costs of providing a given recreation experience (cost-reducing technical change) and (b) those due to an increase in the quality of recreation experiences for a constant cost (quality-increasing technical change). Cost-reducing technologies primarily affect the recreation management production process, and quality-increasing technologies affect the recreation experience production process (Figure 1). Examples of cost-reducing technologies might include a more efficient recreation planning system or lower cost techniques or materials for constructing or maintaining facilities, trails, and so on. An example of quality-increasing recreation technology is dispersal systems designed to spatially or temporally spread people out on a recreation site. Overcrowding decreases the perceived quality of a recreation experience for most people, especially for wilderness recreation, in addition to creating undesirable environmental impacts. Washburne and Cole (1983) surveyed wilderness managers about their most significant problems, and the most frequently mentioned problem was local resource degradation and lack of solitude as a result of concentrated use. Other examples of quality-increasing technical change in recreation management include methods to help manage for a variety of recreation experiences, such as the Recreation Opportunity Spectrum, or ROS (Driver, Brown, Stankey, & Gregoire, 1987). Variety increases consumer satisfaction and perceptions of quality for certain types of recreation (e.g., Milton & Clemmons, 1991).

Figures 2a and 2b illustrate the economic effects of these two types of benefit. Both figures represent the final recreation market. The vertical axes in the figures represent the per unit price or willingness to pay (WTP) for a given type of recreation (e.g., WTP per RVD), and the horizontal axes represent the total quantity of a given type of recreation (e.g., the number of RVDs).

In Figure 2a, the adoption of a recreation management technology resulting from research reduces the marginal cost of providing a given recreation experience. The reduced cost is shown by the downward and rightward shift in the recreation supply curve from S_1 to S_2 , which increases the quantity of recreation experiences demanded from Q_1 to Q_2 and decreases the equilibrium "price" or WTP from P_1 to P_2 . The result of the supply shift is an increase in economic surplus shown by the shaded area in Figure 2a.³

²The exception is new activity technologies. This type of technology, however, is rarely the result of public sector recreation research, which is the focus of this article.

³See Just, Hueth, and Schmitz (1982) for an exhaustive discussion of the concept of economic surplus in economic analysis.

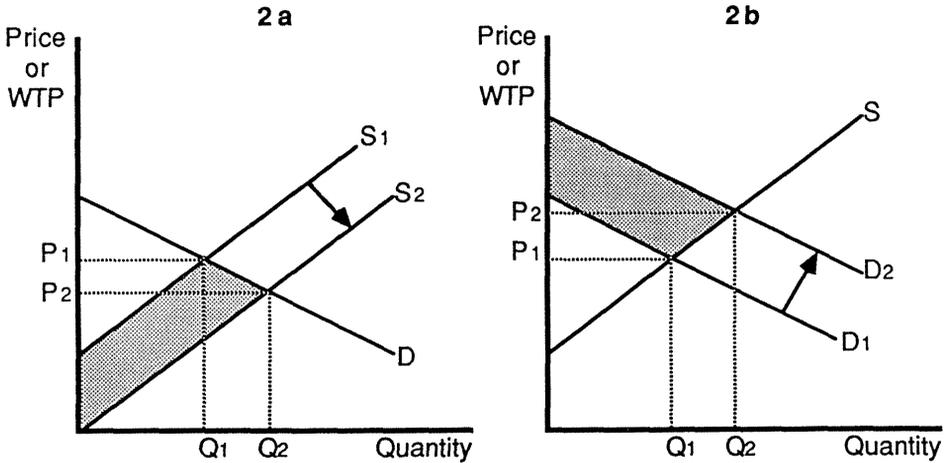


Figure 2. Conceptual framework for estimating recreation research benefits due to (a) adoption of cost-reducing recreation management technologies and (b) adoption of quality-increasing technologies.

The shaded area is a measure of the gross economic gains to society resulting from adoption of a cost-reducing recreation management technology. This assumes that the cost-reducing technology does not affect the perceived quality of the recreation experience. If perceived quality is adversely affected (e.g., due to overcrowding at the higher equilibrium quantity demanded), this would produce a downward and leftward shift in the demand curve, which in turn would lower the quantity of recreation experiences demanded and decrease the economic gains due to adoption of the technology. Figure 2a also assumes that adoption of the technology results in a parallel shift in the supply curve.⁴ The present value of the gain in economic surplus can be compared with the present value of research costs required to develop the cost-reducing technology to estimate the social returns to the investment in recreation research.

Algebraically, gross annual research benefits (GAR_B) due to a supply shift can be calculated as

$$GAR_B = kP_2Q_2 \left\{ 1 + \frac{1}{2} \left(\frac{k}{n+e} \right) \right\},$$

where k is the percentage increase in recreation consumed attributable to research (i.e., the horizontal distance between S_1 and S_2 divided by Q_2), P_2 is the equilibrium price of recreation after the supply shift, Q_2 is the equilibrium quantity of recreation produced, and n and e are the price elasticities of demand and supply, respectively (Hertford & Schmitz, 1977). GAR_B can be further broken down into its consumer and producer surplus components. Unfortunately, the data needed to calculate GAR_B for the case of wildland recreation research would be difficult if not impossible to obtain: Time series data for each of the variables are required for the entire period in which research benefits accrue.

⁴A parallel supply shift implies that adoption of the innovation has the same effect on the average costs of marginal and inframarginal suppliers of recreation opportunities. See Lindner and Jarrett (1978) for a discussion of the nature of supply shifts due to research and technical change.

Table 1
Taxonomy of Wilderness Recreation Benefits

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- I. Personal benefits (accruing primarily to individuals; might or might not benefit society at large)
 - A. Developmental (desired changes in self-concepts and skills)
 - 1. Self-concept
 - 2. Self-actualization
 - 3. Skill development
 - B. Therapeutic/healing
 - 1. Clinical
 - 2. Nonclinical (stress mediation/coping)
 - C. Physical health
 - D. Self-sufficiency
 - E. Social identity and bonding (development/maintenance of desired social relations with family and others)
 - F. Educational
 - G. Spiritual
 - H. Esthetic/creativity
 - I. Symbolic (benefits from options to realize that actions are being taken in support of preservation-related beliefs)
 - 1. Resource stewardship
 - 2. Antianthropocentrism/moralistic
 - 3. Option demands
 - 4. Other
 - J. Other wilderness recreation-related benefits to individuals
 - K. Commodity-related (benefits to individuals from goods produced from wilderness such as those related to water and to grazing by domestic animals)
 - L. Nurturance
 - II. Social benefits (accruing across individuals to society collectively or to large segments of society)
 - A. Aggregate personal benefits
 - B. Spinoff benefits
 - C. Historical cultural benefits
 - D. Preservation-related benefits
 - 1. Representative ecosystems
 - 2. Species diversity
 - 3. Air visibility
 - 4. Unique landforms, including areas of outstanding scenic beauty
 - 5. Historic sites
 - 6. Educational values
 - 7. Scientific laboratory
 - 8. Stewardship (option for future generations)
 - E. Quality of life
 - F. Commodity uses (water, minerals, grazing, etc.)
 - G. Economic benefits
 - 1. National economic development
 - 2. Local/regional economic development
 - III. Inherent/intrinsic (benefits to nonhuman organisms)
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Note. From "Wilderness Benefits: A State-of-Knowledge Review" (p. 298) in *Proceedings—National Wilderness Research Conference: Issues, State-of-Knowledge, Future Directions* by B. L. Driver, R. Nash, and G. E. Haas, 1987, Ogden, UT: USDA Forest Service.

Particularly problematic is estimating the supply shift factor k , which involves statistically isolating the supply shift due to research from other factors that shift the supply for recreation.

Figure 2b illustrates the economic effects of adoption of a recreation management technology that improves the quality of a recreation experience. Quality improvement leads to an upward and rightward shift in the ordinary demand curve for recreation from D_1 to D_2 . At the new equilibrium, the price, or WTP, per unit of recreation increases from P_1 to P_2 and the quantity demanded increases from Q_1 to Q_2 . The shift of the demand curve results in an increase in economic surplus represented by the shaded area in Figure 2b.⁵ This assumes that the quality-increasing technology does not affect the cost of production of the recreation experience (which would result in a supply shift) and that adoption of the technology results in a parallel shift in the demand curve. The present value of this economic surplus gain can be compared with the present value of research costs to develop the quality-increasing technology to estimate the social returns to the research investment. See Unnevehr (1986) for a formula for estimating GARB due to a demand shift resulting from research that improves quality.

It may be the case that some cost-saving recreation technologies reduce the perceived quality of the recreation experience, producing a backward shift in the demand curve in Figure 2a. For example, an interactive, computerized system may be an efficient, cost-reducing means to provide on-site information to recreationists (Forsberg, 1990). Such a system, however, may detract from the perceived quality of the recreation experience, especially in a wilderness setting, for recreationists who view it as an unwelcome technological intrusion. In this case, the welfare loss due to the backward demand shift would have to be subtracted from the welfare gains from the downward supply shift to determine the net effect on economic welfare. Similarly, if a quality-increasing technology results in higher costs (an upward shift in the supply curve in Figure 2b), then the welfare loss due to this supply shift would have to be subtracted from the welfare gains due to the outward demand shift to determine the net economic effect.

In addition to new management technology, many other factors will shift recreation supply and demand curves over time. The availability or price of land that is suitable for recreation activities will affect the supply of recreation. For example, the U.S. Department of Agriculture (USDA) Conservation Reserve Program has taken farmland out of agricultural production, increased wildlife habitat, and probably shifted out the supply for certain types of recreation activities such as hunting. Changes in the price of other inputs needed to provide recreation opportunities (e.g., labor, capital, energy, and materials) will also affect supply. Many factors also shift recreation demand over time, such as changes in disposable income levels, leisure time, population growth, the age distribution of the population, and regional shifts in population. From the perspective of evaluating the economic impacts of recreation research, however, we are only interested in supply and demand shifts due to technical change.

A possible third category of economic benefits relates to protecting or restoring wildland resources. One of the objectives of recreation managers is to limit the undesirable environmental impacts of recreational use, that is, "to find the proper balance between satisfying public desires for recreational experiences without creating substantial irrevers-

⁵A recreation management technology may also increase the quality of the recreation experience by limiting supply (e.g., a visitor quota system). In this case, the quantity demanded will remain the same or actually decline from what it was before the technology was adopted, and the economic gains will be less than in the situation shown in Figure 2b.

ible losses of wildland resources'' (Hammitt & Cole, 1987, p. 18). This objective is often required by management regulations or by law. Many new recreation management technologies are intended to help managers reduce or avoid harmful environmental impacts, for example, site hardening and shielding techniques; systems for rationing, dispersing, or concentrating recreation use, and so forth. The model for determining the limits of acceptable change (LAC) is a good example of this type of recreation management technology (Stankey, Cole, Lucas, Peterson, & Frissell, 1985). Technologies that help managers protect or restore wildland resources obviously have environmental benefits, and they will also have net economic benefits if aggregate willingness to pay for the environmental improvements is greater than the costs of developing and implementing the technology and the possible costs due to reduced satisfaction of recreationists. For example, fixed itinerary systems attempt to reduce environmental impacts by restricting visitor freedom (Stewart, 1989), which may reduce willingness to pay for a recreation experience. Visitor dispersal systems, on the other hand, reduce environmental impacts and overcrowding simultaneously and thus may increase recreationists' willingness to pay.

Examples of Recreation Management Technologies

Table 2 lists the 10 most frequently mentioned recreation management technologies identified by Forest Service recreation managers and researchers in an open-ended survey (D. H. Anderson & Schneider, 1993). All three types of recreation management technologies identified earlier were mentioned by respondents. The ROS was most often mentioned as having improved recreation management over the past 20 years, with 40% of respondents listing ROS or similar technologies to manage for diversity. Techniques for determining acceptable levels of impacts associated with wildland recreation and reducing these impacts (such as the LAC system) were mentioned by 29% of respondents.

Table 2 also shows rankings of the perceived importance of each technology in terms of its contribution to achieving three management goals: increasing the efficiency of providing recreation opportunities, improving the quality of recreation experiences, and decreasing unwanted environmental impacts. The first two management goals roughly correspond to our categories of cost-reducing and quality-increasing technologies. It is interesting to note that the most frequently mentioned technology (ROS) is not considered the most important for achieving any of the management goals. ROS ranked 4th most important for increasing efficiency, 5th for improving quality, and 10th for decreasing undesirable impacts. "Techniques to promote better visitor information and education" was mentioned by about one quarter of all survey respondents and was ranked as most important for increasing efficiency and improving quality and 3rd most important for decreasing environmental impacts.

Research Evaluation Models and Application to National Forest Recreation

The recreation management technologies identified in Table 2 have been helpful in achieving various goals of recreation managers (D. H. Anderson & Schneider, 1993). This does not, however, imply that the economic benefits due to these technologies have been greater than the cost of developing and implementing them. Figures 2a and 2b present an idealized framework for evaluating the economic impacts of recreation research, but one that is probably not useful for an empirical evaluation because of a lack

Table 2
Important Recreation Management Technologies Identified by
Forest Service Recreation Managers

Recreation Management Technology	Percentage of Respondents Listing	Relative Importance to Achieving Management Goals ^a		
		Increasing Efficiency	Improving Quality	Decreasing Impacts
1. Methods such as the Recreation Opportunity Spectrum (ROS) to manage for diversity	40.0	4	5	10
2. Ways to determine limits of acceptable change (e.g., LAC)	29.0	8	8	2
3. Techniques to promote better visitor information and education	24.1	1	1	3
4. Techniques to measure visitor behavior, attitudes and perceptions	20.1	2	2	9
5. Techniques such as the Visual Management System (VMS) to manage visual resources	16.0	10	4	6
6. Computer techniques for visitor management (e.g., MISTIX, PARVS)	13.9	6	9	8
7. Methods and processes to involve the public in resource decisions	13.9	5	3	7
8. Methods to decrease resource degradation (e.g., site hardening, etc.)	13.9	7	7	1
9. Techniques to monitor social and physical resource conditions	13.1	9	6	4
10. Techniques to manage visitors directly and indirectly (e.g., fees, permits, zoning, etc.)	13.0	3	10	5

Note. Data from "Using the Delphi Process to Identify Significant Recreation Research-Based Innovations" by D. H. Anderson and I. Schneider, in press, *Journal of Park and Recreation Administration*, 11, p. 31, 32.

^aAverage rankings of perceived importance to achieving management goals, where 1 is most important and 10 is least important.

of required data and the problems inherent in specifying a variable to capture changes in the state of recreation management technology in an econometric analysis. Stier and Bengston (1992) commented on this problem in a review of econometric studies of technical change in forestry:

Perhaps the most severe theoretical limitation of all the studies examined is their use of a time trend as a proxy for the state of technology. There is no

reason to suppose that technical change occurs in a smooth, orderly manner; indeed, the literature on diffusion of technology and technological forecasting suggests that it often occurs in spurts . . . The linear time trend is also often highly correlated with output or prices. Thus, its use not only implies an incorrect measure of changes in the state of technology; it also frequently introduces statistical problems into the model and forces the researcher to simplify the model structure by making *a priori* assumptions. (Stier & Bengston, 1992, p. 153)

Several approaches have been developed by technological forecasters for representing the state of technology based on the function the technology performs and key technical parameters (Martino, 1983). For example, scoring models, constrained scoring models, and trade-off surfaces have been used to calculate indexes of technical change in cases where several technical parameters are important, such as the speed, energy consumption, and precision of machinery. These approaches, however, are suitable mainly for measuring technical change in manufacturing production processes and other areas in which changes in technology are embodied in improved equipment. They are much less relevant and have not been applied to technical change that is "disembodied" (i.e., technical change that consists of better methods and organization), such as management technology in general and recreation management technology in particular. The complex production processes associated with wildland recreation and the lack of markets for valuing many inputs and outputs combine to stretch traditional economic approaches to evaluating the economic impacts of research and technical change in recreation beyond its limits. The tools of economic analysis are indeed blunt instruments for assessing the value of technical change in areas such as wildland recreation.

Given these difficulties, this section presents two evaluation approaches that are both useful and practicable: an aggregate cost-price model and a congruence, or research intensity, model. The purpose of these evaluation approaches is to address the question: Has society over- or underinvested in recreation research?

Cost-Price Approach

A cost-price evaluation approach (sometimes called a break-even or threshold benefit analysis) avoids some of the difficulties of traditional cost-benefit analysis in situations where benefits are difficult to quantify in monetary terms, but still provides useful information for decision making. Evaluation approaches of this type have been used to analyze projects and programs in many fields, including forestry. In the case of recreation research, the cost-price or threshold benefit is defined as the minimum dollar value that research benefits must attain for the benefits to equal the cost of the research that produced the benefits. The resulting values do not tell us the level of economic benefits of recreation research, but do reveal what level the benefits must be to justify the research expenditures.

Cost-prices are derived from the same discounting-compounding formulas used in cost-benefit analysis and other investment analysis calculations. For the case at hand, we want to compound past recreation research expenditures to present value terms and equate them with the incremental benefits due to research, where benefits are expressed on a per RVD basis. In other words, we want to solve the following equation (which equates research costs and benefits) for $PV(\Delta WTP)$:

$$PV(\Delta WTP) \cdot (RVD) = PV(C),$$

where PV represents present value (ΔWTP) represents the change in willingness to pay for recreation activities due to research, RVD is the total number of recreation visitor days over the time period of interest, and $PV(C)$ is the sum of the present value of research costs,

$$PV(C) = \sum_{n=0}^N C_n(1+i)^n,$$

where the summation is over the relevant time period, from $n = 0$ to $n = N$.

A complicating factor in the evaluation of research impacts is that there will be a time lag between the expenditure of funds and the realization of benefits. It typically takes several years to develop and disseminate research findings. Various approaches have been used in the research evaluation literature to account for this lag (J. Davis, 1979). The simplest procedure (and by far the most conservative one) assumes that all benefits from research expenditures in a given year are realized in a single year, which occurs a fixed number of years after the expenditure date. Other approaches to dealing with research lags that have been used assume that research benefits occur after a fixed interval, but that this same return then continues into perpetuity, or that lagged benefits increase for a time, reach a peak, and then decay back to zero (J. Davis, 1979). The assumption that all benefits occur in a single given year after the research expenditure is extremely conservative and will result in an upper bound or highly conservative estimate of the cost-price for recreation research. For agricultural research in the United States, the consensus of several econometric studies that investigated research lags suggests a mean lag of 6–7 years. Lacking an estimate of the research lag for recreation, we use two lags, 5 and 10 years, which should bracket the “true” lag.

Applying this cost-price approach to National Forest recreation, $RVDs$ are the total number of recreation visitor days on National Forests for the period 1971–1990 and $PV(C)$ is the sum of Forest Service recreation research costs compounded to 1989 present value terms for the period 1966–1985 for a 5-year research lag and for the period 1961–1980 for a 10-year lag. Annual research expenditures were expressed in constant 1989 dollars, using the Consumer Price Index. Bengston (1989b) showed that the rate of inflation in Forest Service research has been very close to broader measures of inflation in the general economy, so a special deflator for research expenditures is unnecessary. A real discount rate of 4% was used, as in the Forest Service RPA Program (USDA Forest Service, 1990a) and in evaluations of other long-term Forest Service investments. The data needed to carry out this calculation are shown in Table 3 (note that research expenditures for the 5 years from 1986 through 1990 were not needed for this calculation due to the 5-year research lag). Given these assumptions and parameters, we obtain the following cost prices or break-even values per RVD :

$$PV(\Delta WTP) = \frac{\$114.509 \text{ million}}{4,401.963 \text{ million RVDs}} = \$0.026 \text{ per RVD}$$

for a 5-year research lag and

$$PV(\Delta WTP) = \frac{\$121.205 \text{ million}}{4,401.963 \text{ million RVDs}} = \$0.028 \text{ per RVD}$$

Table 3
Data for the Cost-Price Evaluation of U.S. Forest Service Recreation Research

Year	National Forest RVDs (millions) ^a	FS Recreation Research Funds (millions of 1989 dollars) ^b	Year	National Forest RVDs (millions) ^a	FS Recreation Research Funds (millions of 1989 dollars) ^b
1961	101.913	1.299	1976	199.928	2.867
1962	112.762	1.619	1977	204.797	3.266
1963	122.582	1.599	1978	218.494	6.030
1964	133.762	2.052	1979	220.166	5.685
1965	160.336	2.390	1980	233.549	3.214
1966	150.729	2.682	1981	235.709	3.666
1967	149.847	2.651	1982	233.438	2.920
1968	156.655	2.733	1983	227.708	2.933
1969	162.838	2.892	1984	227.554	2.122
1970	172.554	3.115	1985	225.407	2.346
1971	178.110	3.214	1986	236.533	
1972	183.958	3.522	1987	238.458	
1973	188.175	3.444	1988	242.316	
1974	192.916	3.683	1989	252.495	
1975	199.201	3.385	1990	263.051	

^aRecreation visitor days on National Forests (USDA Forest Service, Report of the Forest Service, 1961–1990).

^bForest Service recreation research expenditures, in constant 1989 dollars (deflated with the Consumer Price Index; USDA Forest Service, Report of the Forest Service, 1963, 1968, 1973–1985. Other years estimated by linear interpolation.)

for a 10-year lag. This tells us that the incremental WTP for improvements in National Forest recreation experiences attributable to Forest Service recreation research would have to be about 3¢ per RVD (in present value terms) to cover past recreation research expenditures. This compares with an average economic value of more than \$18 per RVD on the National Forests in 1989.⁶ In other words, the value added by past Forest Service recreation research would only need to be extremely small—almost negligible—to justify past research expenditures in economic terms. The low cost-price, together with Cole's (1990) assertion that "the foremost success stories in wilderness management . . . have all been based on a substantial foundation of research" (p. 19) and Anderson and Schneider's (1993) survey of recreation managers indicating the widespread use of research innovations, may suggest that Forest Service recreation research has been a high payoff investment. A more realistic specification of the time lag between research and benefits would result in an even smaller cost-price per RVD.

The preceding cost-price estimates fail to account for "spillovers" of recreation research costs and benefits. As an example of a positive spillover, or spillover of research benefits, new recreation management technologies developed through Forest Service re-

⁶Weighted average of the value of all types of recreation activity on National Forests, from data contained in USDA Forest Service (1990b). This average includes a mix of relatively low-value recreation activities (e.g., camping, picnicking, and swimming) and high-value activities (e.g., winter sports, hunting, and fishing).

search have been used in managing recreation activities on land other than the National Forests. These benefits are not accounted for in the cost-prices calculated above. Recreation research costs also spill over: Recreation management technologies developed through research funded by other federal and state agencies have undoubtedly been used to manage recreation on the National Forests.

The Research Intensity Model

Another way to evaluate recreation research is the research intensity ratio approach, also known as the parity or congruence model. The basic idea in this approach is that the ratio of research expenditures to the value of output for a given sector, commodity, or economic activity should be roughly congruent with the research/output ratio for other sectors. This is based on the premise that the return from an additional dollar is highest if invested in research with the lowest research/output ratio. For this to be unequivocally true two conditions must be met (Ruttan, 1982). First, opportunities for technical change must be equal across the different categories of research being compared; second, the value of research innovations for a given area of research must be proportional to the value of production in that area. If these conditions are met, then, from an economic perspective society is underinvesting in areas of research with relatively low research intensities. Although it is unlikely that both conditions will be exactly met, it is often asserted that the congruence model is a useful first step in analyzing research resource allocation in the absence of specific information about the economic benefits of research and that significant departures from congruence between areas of research may be a red flag for research managers and policymakers. Boyce and Evenson (1975) reviewed the evidence on the congruence between research expenditure and gross value of agricultural commodities worldwide and found that stronger and more mature agricultural research systems tended to be closer to congruence than weaker research systems and that most systems have moved toward congruence over time.

Various formulations of the congruence model have been proposed. Research intensity ratios are the simplest formulation, that is, the ratio of research expenditures to the value of production:

$$RI_i = \frac{r_i}{P_i Q_i} ,$$

where RI_i is the research intensity ratio for commodity or sector i , r_i is research expenditure on commodity i , and $P_i Q_i$ is the gross market value (Price \times Quantity) of commodity i . When market prices are not available, gross economic value in the denominator can be calculated by using the concepts of economic surplus. Another formulation of the congruence model was given by Fox (1986) as follows:

$$CR_i = \frac{r_i/R}{P_i Q_i / \sum_{k=1}^n P_k Q_k} ,$$

where the summation is from $k = 1$ to $k = n$ commodities being considered, CR_i is the congruence ratio for commodity i , r_i is research expenditure on commodity i , R is the total

research budget for all commodities, $P_i Q_i$ is the gross market value of commodity i , and $\sum P_k Q_k$ is the gross market value for all n commodities being considered in the research budget. In this formulation, perfect congruence exists when $CR_i = 1$ for all areas of research being compared.

As an example of the research intensity approach, Table 4 shows research intensity ratios for forestry and agriculture by region in 1980. The forestry ratios vary among regions, and in Africa, Asia, and Latin America are less than half of those in Western Europe and North America, indicating low forestry research intensity in developing countries. Expenditure ratios for agricultural research are 10 to 15 times greater than those for forestry in Africa, Asia, and Latin America. In this table, value of production in forestry includes only the market value of forest products and excludes the value of nonmarket goods and services of forests, such as fuel wood, recreation, wildlife, and so forth. Thus, the value of production is greatly underestimated in the case of forestry, and the forestry research intensity ratios are consequently overestimated, that is, the true ratios are even smaller than those shown. The implication of these ratios being so far out of congruence—given the assumptions of the congruence model—is that forestry research is seriously underfunded in certain regions.

Research intensity ratios for U.S. Forest Service recreation research and all Forest Service research were calculated for fiscal year 1989, the most recent year for which data were available. Appropriated funds for Forest Service recreation research in 1989 were \$2.143 million (E. Dickerhoof, 1992, personal communication), and appropriated funds for all Forest Service research amounted to \$137.867 million (USDA Forest Service, 1990c). The gross economic value of recreation on the National Forests in all regions of the United States in 1989 was estimated to be \$4,479.3 million (USDA Forest Service, 1990b). The gross economic value of all outputs of the National Forests—including timber, recreation, minerals, range, water, and wildlife and fish—amounted to an estimated \$15,941.1 million across all regions in 1989. (USDA Forest Service, 1990b). Both of these estimates of economic value are based on economic surplus concepts, that is, an accounting framework that includes estimates of market clearing prices plus consumer surplus.

Using this data, the research intensity ratio for Forest Service recreation research is 0.00048. This compares with an intensity ratio for all Forest Service research of 0.0086.

Table 4
Research intensity ratios for forestry and agriculture, 1980.

Region	Research Expenditures as a Percent of Value of Production	
	Forestry	Agriculture
Africa	0.122	1.272
Asia	0.075	1.117
Latin America	0.053	0.887
W. Europe	0.267	1.456
E. Europe & USSR	0.148	0.690
N. America & Oceania	0.269	1.243

Note. Adapted from "Forestry Research: A Provisional Global Inventory" by F. Mergen, R. E. Evenson, M. A. Judd, and J. Putnam, 1988, *Economic Development and Cultural Change*, 37(1), p. 160.

Perhaps it would be more relevant to compare the recreation research intensity ratio to the intensity ratio for all other Forest Service research. When recreation research expenditures are subtracted from total Forest Service research expenditures, and recreation value is subtracted from the gross economic value of all National Forest outputs, the research intensity ratio for all nonrecreation research is 0.0118. Thus, the intensity of recreation research is almost 20 times less than all Forest Service research and about 25 times less than all nonrecreation research, and some evidence is given of an underinvestment in recreation research. As mentioned earlier, a significant departure from congruence in research intensity ratios is typically interpreted as a red flag that may warrant closer examination rather than as a sole basis for research resource allocation.

Conclusions and Implications

This article has highlighted some key conceptual issues related to evaluating the economic impacts of wildland recreation research. Evaluation of recreation research is complicated by several factors that have surfaced throughout the article. The nature of the outputs of recreation management and recreation experience production processes (Figure 1) is one such complicating factor. The production of recreation opportunities and recreation experiences is far less tangible than the production of wood products, agricultural commodities, and industrial innovations that have been the focus of most research impact evaluations. For example, Brown and Manfredo (1987) discussed the complex cognitive and physiological processes involved in transforming recreation experiences into individual and social benefits.

Another complicating factor is the nature of the outputs of recreation research. The recreation management technologies listed in Table 2 (with the exception of Number 8, methods to decrease resource degradation) are all the products of social science research. Research evaluators have focused their attention on capital-embodied production technologies, and very few studies have attempted to quantitatively measure the impacts of management technologies or social science research (Bengston, 1989a). Some of the attempts that have been made have not been very successful, such as Norton's (1987) evaluation of the impacts of agricultural economics research. This lack of progress is largely attributable to problems in measuring the output and extent of adoption of social science research and in determining the causality of change that occurs following such research. New knowledge produced by social science research in recreation is not usually embodied in tangible and readily measured items such as new inputs or products. Rather, if successfully adopted and implemented, it is embodied in improved decision making and in more efficient or effective management practices or policies. Establishing the causality of change that occurs as a result of social science research is problematic. Research on the utilization of social science research has shown that managers often use social science research findings indirectly as a source of ideas and orientations to the world instead of applying specific findings to specific decisions. Weiss (1980, p. 381) has termed this indirect use of research as "knowledge creep and decision accretion" and refers to the "enlightenment function" (p. 531) of social science research. Thus, due to the elusive nature of the outputs, evaluation of the economic impacts of social science research may not be possible given our limited ability to analyze empirically.

Finally, the institutional setting for wildland recreation complicates the evaluation of recreation research. Recreation on public lands has traditionally been provided outside of competitive markets, and the nonmarket nature of public wildland recreation poses challenges for research evaluators. Economists have developed several methods for estimating

the economic benefits of recreation and have applied these methods to a large number of recreation activities (see Sorg & Loomis, 1984; Walsh, 1986). The methodology for nonmarket valuation is controversial, however, and a large body of criticism has been produced in recent years that points out the conceptual and practical problems with these valuation approaches (e.g., see Anonymous, 1992).

Estimating the incremental economic value attributable to recreation research is even more problematic, however. Markets for many of the inputs and outputs of the three production processes identified in Figure 1 do not exist or are poorly developed. The critical problem is how to value the outputs of recreation research given that traditional markets for these outputs do not exist; recreation management technologies are not sold to recreation managers. They are usually published and made available to managers through a variety of channels. It is unlikely that recreation managers could provide meaningful estimates of the economic value of technologies because of the great uncertainty surrounding the nature and magnitude of benefits from untried innovations. It may be possible to obtain meaningful estimates of the incremental contribution of new management technologies to the value of recreation activities directly from recreationists, applying the contingent valuation method that is frequently used to obtain estimates of recreationists' willingness to pay for various recreation activities. Although possible, this approach would involve a number of difficult problems, and in the end would at best provide a lower bound estimate of the economic benefits of recreation management technologies. One of the main justifications for public provision of recreation opportunities is the argument that recreation provides a variety of social benefits, that is, benefits to society beyond those accruing primarily to individual participants. Estimates of individual recreationists' incremental willingness to pay would, by their nature, only capture part of the benefits to society.

Taken together, these three factors strongly suggest that the evaluator's reach may exceed his or her grasp in any attempt to use traditional approaches to evaluate the economic impacts of wildland recreation research. Yet decisions have to be made about the allocation of research resources among different areas of research, and justifications of existing and proposed research programs are needed. Alternative evaluation approaches must be used. The cost-price and research intensity ratio approaches presented in the preceding section are two possibilities. These evaluation approaches have minimal data requirements and could easily be applied to other research areas for comparison. Another approach would be to systematically identify and describe the beneficial consequences of investment in recreation research. The taxonomy of recreation benefits in Table 1 (from Driver, Nash, & Haas, 1987) could serve as a checklist for such an evaluation method.

It would be naive to imagine that decisions about research resource allocation are or should be made primarily on the basis of economic efficiency. Such decisions are often political in nature. Without some basis for comparison to other areas, however, noncommodity research such as wildland recreation may suffer in the budget process relative to those areas of research that have clearly defined and market-valued outputs. The result could be an underinvestment in noncommodity research. We cannot conclude with a high degree of certainty that recreation research has in fact been underfunded based on the cost-price and intensity ratio analyses in this article; however, the results do suggest the need for further analysis to address this important question.

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