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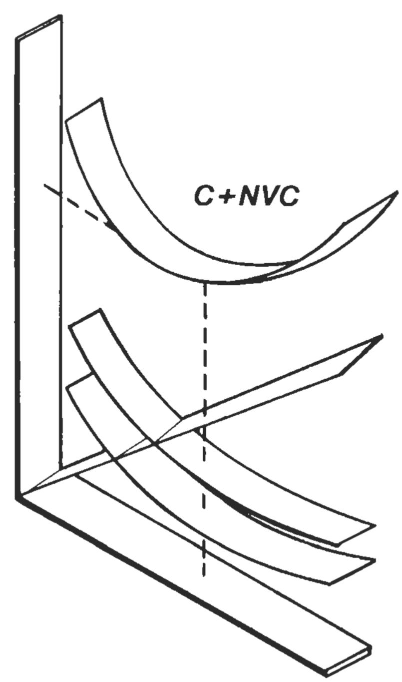
Methods for Assessing the Impact of Fire on Forest Recreation

Henry J. Vaux, Jr. Philip D. Gardner Thomas J. Mills



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Cover: Recreationists were shown photographs taken of a recreation site before (top) and after (middle and bottom) a wildfire, and asked about their willingness to pay an entrance fee to the site.

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IN BRIEF

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Are methods for measuring outdoor recreation demands sensitive to quality differences caused by fire in forest environments? And what methods are the most suitable for estimating recreation demand and values in fire-affected forest situations? A literature search and an experiment were conducted to answer those questions.

Both economic and psychological methods could be used to evaluate the effects of fire on forest recreation. These methods rely on direct and inferential means to assess the values of outdoor recreation. The most suitable of these approaches appears to be contingent market valuation—a direct, economic technique that uses personal interviews. A hypothetical market transaction environment is set up within which values are estimated.

This approach has been used to assess the impact of insect infestations and of timber cutting on forest environments. The effects of such infestations and cuttings are similar to the effect of fire. Recreationists' preferences for visual qualities of the landscape are measured by having them rate photographs according to relative attractiveness. These photographs vary from no insect damage or no cutting to changes in scenic attributes caused by these disturbances. This approach seemed appropriate to the study of the impact of fire on outdoor recreation values.

An illustrative application of this contingent market valuation approach was undertaken with 69 students at the University of California, Riverside. They were shown pairs of photographs identified as typical National Forest sites available for recreational activites. Each person was asked to express a preference among the paired photographs. These pictures depicted scenes before and after a fire. In addition, the respondents were asked about their willingness-to-pay an entrance fee to a recreation site by an iterative bidding procedure. A mathematical equation was developed to compute the present discounted value of the recreation activity in a fire-free site and in a fire-affected site, and to estimate the respondents' willingness-to-pay.

The illustrative results suggest that less intense fires may have beneficial economic effects, whereas intense fires may have detrimental effects on recreation values. The valuation of the impact of fire was not always negative or unanimous among respondents, and preferences are subject to change. Willingness-to-pay is an appropriate measure for valuing the effects of fire on forest recreation.

Efforts to evaluate the effects of fire on natural resources have focused largely on impacts that are commonly measured in monetary terms, such as losses of commercial timber, grazing yields, and structures. The effects on the generally unmarketed resources, such as watershed, fish, wildlife, and recreation, have been considered in policy directives, but the economic implications of the effects of fire on these forest amenities have not been fully understood. These latter resource categories have figured less prominently in fire management program evaluations partly because they are not usually traded in markets.

Recreation is one resource that is least subject to market allocation, and the economic literature on outdoor recreation presents a varied and sometimes conflicting array of conclusions. Investigators have reached no consensus on the magnitude of recreation benefits or the appropriate methodologies for estimating these benefits. Successful attempts to isolate the value of individual attributes of the outdoor recreation experience have been few.

Efforts to assess the impact of fire on recreation usage and value are even more sparse. The fact that fire affects only selected site attributes, and also affects the path of those attributes over time further confounds the measurement problem (Davis and others 1980). The measurement problems can be diagramed: Initial State → State A → State B → State C. Given some initial state and the absence of fire, a specific habitat will evolve along a successional continuum to subsequent states, labelled A, B, and C for simplicity. If a fire occurs at the initial state, a different successional trajectory will follow with States A′, B′, and C′: Initial State → State A′ → State B′ → State C′.

This report assesses the degree to which current methods for measuring recreation demand are sensitive to quality differences caused by fire in different forest environments, and recommends methods for estimating recreation demands and values in a fire-affected situation.

VALUING OUTDOOR RECREATION

Work on valuing unmarketed commodities has led to two distinct approaches. Direct techniques rely on survey instruments and interviews to query recreationists directly about the values they ascribe to recreation. Inferential techniques infer from observed behavior the willingness of a person to pay for outdoor recreation activities. Both approaches are based on the theory that the total value of the commodity is measured by the consumer's willingness-to-pay for it. Consumer surplus is the amount a consumer would be willing to pay for a commodity *in excess* of what he actually pays (Mishan 1959). Graphically, consumer surplus is approximated as the area under the Marshallian demand curve in excess of the prevailing price (*fig. 1*). The shaded area ABP_1 is the total consumer surplus when the prevailing price of a marketed good is P_1 (*fig. 1*). Where the good is not priced because of the absence or failure of markets, the consumer surplus is the entire shaded area under the Marshallian demand curve, ACD (*fig. 2*). The consumer surplus for unpriced goods is equivalent to total willingness-to-pay.

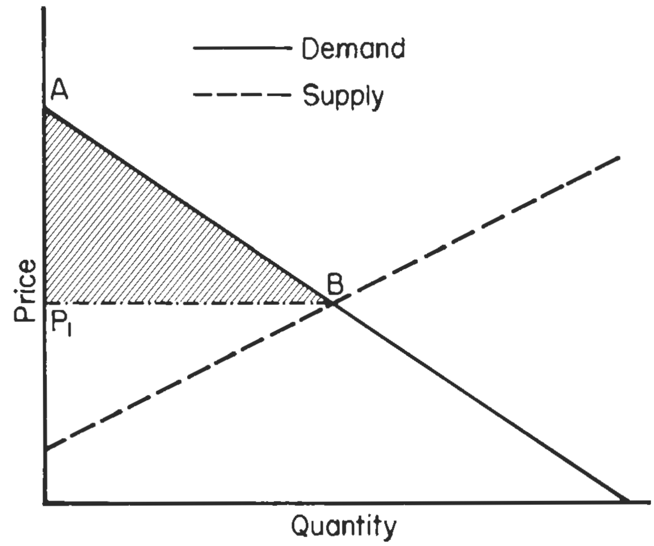


Figure 1—Consumer surplus—what a consumer is willing to pay beyond what is actually paid—is represented by the shaded area, with the prevailing price of a marketed good shown as P_1.

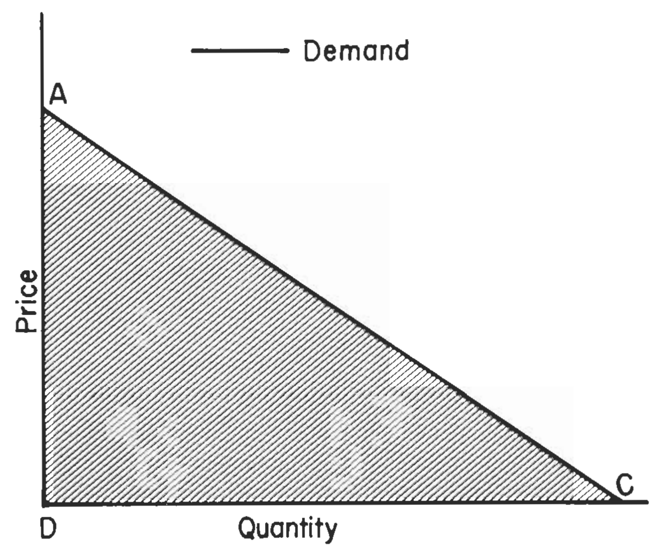


Figure 2—The shaded area under the demand curve represents consumer surplus where no market price exists—what the consumer is willing to pay beyond what is actually paid.

Inferential Techniques

The premise behind inferential techniques is that willingness-to-pay can be inferred from the observed consumer behavior. In general, inferential models are useful where the commodity or its attributes can be specified quite explicitly. Three classes of inferential models exist: (a) travel-cost demand, (b) consumer theory, and (c) gravity. We focused on travel cost demand models because they have been used more extensively in recreation studies than the other two classes.

In implementation of the travel cost demand method, the analyst first specifies a number of travel zones from a recreation site (see for example, Cicchetti and others 1972, Clawson 1958, Hotelling 1938, and Pearse 1968). The residence of each recreationist is then used to estimate his or her participation rates for each travel zone. The inverse relationship between participation rates and distance from the recreation site is the basis for constructing the demand curve. Recreationists from the furthest travel zone are assumed to be the marginal consumers. The consumer surplus of the site is estimated as the sum of the rents per unit of activity for all points of origin multiplied by the number of trips from each origin. All other consumers are assumed to react to an increased entrance fee to a recreation site in the same way that they would react to an increase in travel costs.

The typical travel cost demand model assumes that (a) tastes and preferences are identical both within and between different distance zones, (b) recreationists react to changes in fees in the same manner as to changes in the travel costs, (c) alternative recreational opportunities are equally available for all populations, (d) travel time is neglected and all consumers have the same opportunity cost for time, (e) the population has homogeneous social and economic characteristics, and (f) all visitors spend the same amount of time at the recreation site.

The travel cost assumptions about homogeneity of tastes, preferences, and alternatives have been refined by analyzing only people who actually participate in recreation and by stratifying them by income class (Pearse 1968). Further substratification within income classes by occupation, age, or other socio-economic variables was suggested as further refinement. The assumptions are still arbitrary, however, and willingness-to-pay varies inversely with the number of arbitrary income classes.

Recreationists react to a host of variables that determines visitation rates—not simply to changes in travel costs alone—and the value of time for travel must also be recognized (Knetsch 1963). Visitation rates may not fall as much in response to fee increases as predicted by the travel costs method (Cesario and Knetsch 1970, 1976). The principal source of bias may be the neglect of travel time and not the failure to account for the total time spent in recreation. The opportunity cost of time spent in recreation cannot, however, be ignored (McConnell 1975, 1976). A study of these conflicting views lead to the conclusion that as a general principle, on-site time costs should be included (Wilman 1980).

The need to include differing qualities of alternative recreation sites has been addressed in several studies. An empirical method to distinguish the quality value of a site from its locational attractiveness proposes that a site quality difference exists when (a) visitation rates to various sites are unequal, or (b) visitation rates are equal although travel costs are unequal (Wennergren and Fullerton 1972). The impacts of individual quality attributes cannot normally be estimated with this method, however, because of the inability to pair sites which are similar in all attributes other than the one under study.

Distortions can be introduced into travel costs demand analysis through data aggregation. The aggregation of data from visitor records usually used to calculate the demand curve of the average individual interjects distortions (Smith 1981). All individuals are represented by the same demand function even though they may engage in different activities during a recreational visit and vary the timing of their visits. The masking of these distinctions through data aggregation could lead to faulty estimates of recreation benefits.

Travel cost demand methods have two distinct advantages. First, they rely on observations of actual behavior by recreationists. This practice is consistent with that of using revealed preference methods common to demand analysis of marketed goods. Second, much of the data used are routinely gathered.

Offsetting these advantages of travel cost models are disadvantages which severely limit their potential use for fire impact analysis. These models are not well suited for estimating the value of individual quality attributes or for estimating changes in value over time. An aspect of the travel cost demand methodology that is a problem is its assignment of values to the entire recreation experience. Wennergren and Fullerton (1972) made some advances in the separation of the value contribution of location and quality characteristics, but they did not provide an *a priori* means for distinguishing between the components of value attributable to specific qualities. The impact of fire affects only selected quality attributes.

The travel cost demand method could be used to estimate the value of specific characteristics only if pairs of sites could be found that were identical in location and quality except for the attribute under investigation, e.g., sites homogeneous in all respects except for fire histories. Alternatively, heterogeneous sites could be used if there were some way to standardize for all differing quality attributes. Either of these solutions to the method's deficiences would, however, increase the costs of data acquisition enormously.

The impacts of fire on the landscape are not static, and inferential methods are especially ill-suited to account for changes over time. Actual recreation behavior over time that would be measured by inferential methods is influenced largely by changing economic and cultural factors as opposed to variation in the physical landscape where recreation occurs (Clawson and Knetsch 1966). In short, because of the problems of measuring the impact of individual site attributes, especially when those attributes change over time, inferential methods do not hold much promise for assessing the impact of fire on recreation.

Direct Techniques

Direct methods of determining consumer willingness-to-pay are characterized by personal interviewing techniques, such as contingent market valuation approaches. In such approaches, a hypothetical market environment is developed within which values are estimated. An interview can elicit the highest possible bid from individual recreationists for the realistic, albeit hypothetical, recreational service or product (Davis 1963). That bid represents the potential user's maximum willingness-to-pay for that service or product. Alternatively, the bid can be considered the minimum compensation required to induce the user to forego the service or product.

Direct questioning techniques have been criticized on two points (Samuelson 1954). Individuals may have incentives to give false bidding signals, i.e., follow some bidding strategy that does not reflect their true willingness-to-pay, dependent upon how they believe their bids may be used in setting fees and depending on the perceived role of the interviewer. Bids given under a hypothetical situation may not be the same as those that would be paid in the real-life situation.

To test for the presence of strategic bidding, Bohm (1971, 1972), designed an experiment to make the choices so complicated that possibilities for strategic behavior would be obscured and consumers would thus state their true maximum willingness-to-pay. Respondents were told that (a) if aggregate bids were too low, the product in question will not be produced; (b) overstated bids would increase the probability that the consumers would have to pay the groups average bid; (c) it was morally wrong to give false bids; and (d) there was no anonymity in the final bids. In other experiments, testing for strategic behavior and hypothetical bias was done by employing different sets of instructions to bidders and by emphasizing five possible bidding-to-payment outcomes (Bohm 1972). The results suggested that hypothetical questions containing a minimum of information tended to induce hypothetical behavior.

The sensitivity of alternative payment vehicles with realistic, if hypothetical, situations related to air quality degradation was tested by the use of photographs (Randall and others 1974). Payment vehicles included (a) sales tax rate increases, (b) added charges to their electricity bills, or (c) increases in park user fees. The bids appeared to be sensitive to the payment vehicle.

In a study of air quality degradation in a scenic area, a single bidding technique was used to test for strategic behavior by postulating that honest bids would be normally distributed (Brookshire and others 1976). The results were roughly consistent with those reported by Randall and others (1974).

The value of visibility reductions was investigated in the Farmington (New Mexico) area in a systematic test for potential strategic, information, and hypothetical biases (Rowe and others 1980). Prior to bidding, some respondents were provided with hypothetical information about the mean bids of other respondents. Those not supplied with this information were told after the bidding and asked if they would change their bid. The findings showed no significant strategic bias. Visibility reduction was also examined in a study of geothermal energy development in the Jemez Mountain region of New Mexico by using a series of photographs and a questionnaire focused on site substitution possibilities (Thayer 1981). The results showed that neither information nor starting point bias was statistically significant. Hypothetical bias was analyzed by comparing the bids and site substitution preferences with estimates of the additional travel costs to substitute sites. An analysis of the incremental cost of travel associated with substitutes provided a useful means to cross-check the validity of bids (Thayer 1981).

Elk hunters in the Laramie (Wyoming) area were surveyed to determine the values which hunters placed on the right to hunt elk, the differing habitats in which elk hunting occurred, and the number of daily encounters with elk (Brookshire and others 1980). No starting point bias was found but bids appeared to be influenced by the payment vehicle. The respondents reacted negatively to the utility bill vehicle, but not to the hunting license fee vehicle.

The results of a contingent market valuation study of air quality impacts were compared with those of a study of real market housing prices (Brookshire and others 1982). The differences in housing values compared quite favorably with the willingness-to-pay bids although the bids were somewhat lower. The bids were sensitive to housing characteristics, levels of income, knowledge of air pollution effects on health, and other characteristics studied.

Although contingent market valuation studies have been viewed with skepticism, a growing literature suggests that much of the skepticism is unwarranted. A review of the major contingent market studies found the results surprisingly consistent (Schulze and others 1981). Strategic and information biases did not appear in most instances where efforts were made to test for their existence. The principal problem remaining is with hypothetical bias and the inability to test for it. Even with hypothetical bias, however, contingent market methods can estimate values of nonmarketed goods that cannot be estimated in any other way.

Contingent markets, even though fictional, generate estimates more consistent with neoclassical consumer theory than do inferential methods (Brookshire and Crocker 1981). Contingent market methods measure the value consumers expect to glean from a nonmarketed commodity, not the value ultimately realized. Inferential methodologies fail to fully account for consumer expectations by estimating the value a consumer actually obtains. Contingent market methods also simplify the problems of accounting for the effects of extraneous and confounding variables. In the absence of more detailed analytical study of how expectations are formed, however, it is not possible to confirm or refute the empirical findings from contingent markets. On the balance, contingent valuation methods appear best suited for evaluating the impact of fire on forest recreation experiences.

METHODS FOR MEASURING IMPACT OF FIRE

Most recreation studies have focused on the quantitative values of the entire recreational experience rather than on the effects of individual forest environment attributes. Two types of studies that measure the value of qualitative changes in forest environments attributable to insect infestations and timber cutting practices are (a) economic studies that measure consumer surplus directly and provide explicit measures of the value of attributes; and (b) psychological studies that focus on the perceptions of recreationists *per se* and do not derive direct measures of economic value.

Economic Tests

Economic studies focus almost exclusively on forest insect infestations, but the effects of such infestations may be similar to the effects of fire. A study of a mountain pine beetle infestation on recreational sites in Idaho used a conventional travel-cost demand model (Michalson 1975). Demand functions for areas with and without pine beetle damage were derived from a questionnaire. The estimated value of each visitor-day (consumer surplus) range from $15.50 for the infested sites to $17.90 for the noninfested sites—a difference attributed entirely to insect infestation. A fundamental problem with that study is that differences in consumer surplus are attributed to a single characteristic of site quality. Such differences can only be attributed to a single quality when all of the other qualities are similar between sites.

A travel-cost demand model was combined with a gravity potential model to estimate the loss in recreation value at campgrounds infested with southern pine beetle in Texas (Leuschner and Young 1978). The major source of data were annual visitation records. Estimated annual damages ranged from $3,500 at sites with a 10 percent level of infestation to $700,000 at sites with a 90 percent level of infestation. Failure to consider substitution possibilities resulted in systematic overstatement of damages.

The economic impact of a gypsy moth infestation was examined in the northeastern United States (Moeller and others 1977). Data from personal interviews showed that all types of property owners were sensitive to infestation by the gypsy moth, though for different reasons. Recreational activity declined by 12 to 52 percent, depending upon the extent of damage and the type of operation.

The shortcomings of these travel-cost demand studies underscore the need to select sites with similar quality attributes, and the difficulty of accounting for substitution possibilities. The work also underscores the significance of the dynamic effects of disturbances in forest environments.

Psychological Tests

Social scientists have developed methods of assessing individual's preferences for the visual qualities of landscapes that focus on the direct specification of utility rather than measurement of consumer surplus (Daniel and Boster 1976, Kaplan and others 1972, Zube 1973). Several of these psychological utility methods have been used to assess the impact of insect infestations and timber cutting practices in forest environments.

Photographs of mountain pine beetle infestation in Idaho were used to assess the impact of insect damage on recreationist's preferences (White 1977). The photographs were selected to standardize for the distance or perspective of view. Recreationists rated the photographs according to the relative attractiveness. The preference analysis revealed that the distance or perspective significantly affected preferences. Close perspectives were preferred over more distant ones, and recreationists reacted more intensely to infestation damage in the near perspectives. The detrimental impact of insect damage was deemed to be offset by the presence of other scenic attributes in the landscape.

In a study of scenic preference functions for forested sites with varying amounts of southern pine beetle damage, training in forestry had no significant effect on preferences (Buhyoff and Leuschner 1978). Preferences for undamaged stands increased sharply as damage levels approached 10 percent, but preferences changed very little to damage levels beyond 10 percent. The inconsistencies between this study and the one by White (1977) show that the research method and the structure of the sample can influence the results.

The attractiveness of forest scenes was measured by focusing on the spatial quality of stands (Brush 1979). The results showed that participants had strong preferences for open stands irrespective of the species composition. This underscores the fact that disturbance phenomena that alter the density of stands over time may lead to evolution of more attractive stands even though the initial visual impact is not attractive. Certain fire-caused tree mortality has the possibility of creating such a stand structure.

The impact of a Douglas-fir tussock moth outbreak on recreation business was analyzed in northeastern Oregon (Downing and others 1977). The majority of interviewees cited factors other than the infestation as being critical determinants of the magnitude of recreation activity.

The more prominent study of preferences for forest attributes focused on the visual impacts of cutting practices in central Michigan (Langenau and others 1977). A series of sites was prepared with cutting controlled at 25, 50, and 75 percent levels. Two sites were prepared at each cutting intensity to control for quality attributes not related to cutting. An "untreated" site cut at a 3.5 percent intensity level was also prepared. Perceptions of individuals residing near the prepared sites were studied in 1974 and 1976 to test the hypothesis that individuals would tend to become "conditioned" to clearcutting, especially as the sites regenerated. The attitudes of those exposed to the cutover sites did not change significantly over the 2-year period, possibly because experience had not altered prestudy attitudes about clearcutting practices. Or perhaps the number of encounters with cutting areas did not increase significantly between the first and second survey.

The relationship between the preferences for cutover landscapes and the diversity of recreation activities on the sites was studied by using the same study area (Levine and Langenau 1974). A recreation activity profile study showed that respondents with high diversity patterns of recreational activity were positively correlated with support for clearcutting practices. Recreationists who engage in a variety of activities were more likely to perceive the positive features of clearcutting than those who engage in only one activity. The intensity of recreation activities, as measured by the number of recreation trips was not related to support for clearcutting.

The impact of clearcut size and the extent of regeneration were related to the participation rates of recreationists and their perceived quality of the recreation experience (Langenau and others 1980). Attitudes toward clearcutting were strongly dependent upon the type of recreation activity. For example, campers were more concerned with the immediate surroundings while others focused on the totality of the landscapes. Relationship of recreational use and perceived site quality to cutting level suggests that the regenerative features of vegetative succession may be an important determinant of perceptions.

MEASURING RECREATION VALUES

Evaluating the impact of wildfire on forest recreation differs in an important respect from valuing other qualitative impacts. The effects of fire depend heavily on time—much more so than most other effects, except impacts from insect infestations and timber harvesting.

Fire can alter the successional path or trajectory of ecosytems over time and the qualitative effects of fire on the landscape may persist over long periods. The fire-free landscape evolves also. Therefore, a recreationist's perception of relative attractiveness of a fire-impacted and nonfire-impacted landscape depends on how much time has elapsed since the fire occurred and the differences in the vegetative succession of the two landscapes.

Depicting Fire Succession

The impact of fire varies with many factors, including the successional stage of the habitat and the intensity of the fire (Davis and others 1980). Any effort to value the impact of fire must be carried out within the habitat and successional context in which the fire occurs.

Contingent market valuation methods using iterative bidding procedures with photographs of similar environments, both with and without the effects of fire, can provide a reasonably straightforward means of standardizing the physical landscape. In fact, photographs appear to be the only practical way to control the factors unrelated to fire.

The photograph sequences can be obtained in two ways. One is to obtain pictures of the same site over time, from a period before the fire through points in the postfire regeneration. When photographs of the initial state are paired with each of the succeeding states, they represent various time points on the successional paths of the fire-impacted and fire-free sites. This is valid if the prefire scene is in a vegetative climax state that would remain unchanged in the absence of fire.

An example of this approach is a photograph sequence in a climax setting in Neal Canyon, central Idaho. The site was initially a Douglas-fir climax habitat type and the scene of an intense fire. The initial, or prefire state, photograph shows a climax state whose appearance over substantial periods of time can be represented by a single photograph (*fig. 3A*). The remaining photographs were taken from the same point 1 day after (*fig. 3B*), 3 years after (*fig. 3C*), 6 years (*fig. 3D*), and 12 years (*fig. 3E*) after the fire. A similar sequence was photographed from a distant perspective: the prefire site, (*fig. 4A*); and 1 days (*fig. 4B*) and 12 years (*fig. 4C*) after the fire.

If the initial state is not in a climax state, it is possible to construct, with the aid of fire ecology experts, sequences of pictures which provide close facsimiles of vegetation successions with and without fire. Care must be undertaken to ensure that extraneous influences are absent. The scarcity of sequence photos together with difficulties in constucting perfectly matched sequences suggest that it may not always be possible to eliminate extraneous influences such as photo orientation and amount of sunlight.

An example of a constructed sequence shows the effect of light ground fire on a ponderosa pine type habitat in the Sierra Nevada of California. They showed a successional trajectory in the absence of fire (*figs. 5A-5D*) and in its presence (*figs. 5E-5H*). These sequences yielded four pairs of photographs depicting the state of the trajectories after identical lapses in time from the initial state.

The three sequences in *figures 3-5* depict scenes that had no especially unique qualities. And so we included a simple sequence of fire in the presence of outstanding scenic attributes, the Garden Wall area of Glacier National Park, Montana—as it was in 1957 (*fig. 6A*), and in 1980 (*fig. 6B*). A major fire occurred in the Garden Wall area in 1967.

Most previous contingent market valuation studies measure only the intensity of preferences, under the implied assumption that the attribute is unanimously desirable or undesirable. There may not be unanimity, or even near unanimity, over which successional state is preferred. It is also possible that different successional paths will be preferred at different stages. A contingent market valuation study must be structured to identify this lack of unanimity and preference shifting.

Evaluating Preferences

To examine this preference structure, we conducted a simple preference rating test among 69 voluntary graduate and undergraduate students at the University of California, Riverside. Each participant was shown pairs of photographs identified as typical National Forest sites available for recreation activities and was asked to choose the preferred site. Each respondent rated the paired pictures from four sequences of pictures shown in *figures 3, 4, 5,* and 6.

The process of eliciting the respondents' preference and bidding was as follows. The interviewer would say:

> These photographs show two similar forest environments. One of the environments has been affected by fire and the other has not. Let's assume that these environments are generally representative of places where you can spend most of your time here in the forest. Do you prefer one to the other? ______________________A
> ______________________B

After the respondent had expressed a preference, we asked:

> Now, let's assume that by paying an entrance fee for your family or group you can be admitted to the recreation site that you prefer. This will be the only way to guarantee that you have access to such sites. Let's also assume that all visitors to the site will pay the same daily group or family fee as you and that all money collected will be used to finance fire control programs designed to preserve and maintain such sites. Would you be willing to pay $1.00 per day family fee to ensure that you could visit the site that you prefer? $2.00 per day?

We used an iterative bidding process in which the original bid was changed by increments of $1.00 per day until a negative response was obtained. Then we decreased the bid by 25¢ per day until a positive response was obtained, and recorded the amount.

The differences in the paired photos were explicitly attributed to fire and a connection was made with recreation activities. This characterized the "good" to be traded in the contingent market as precisely as possible. The payment vehicle—an entrance fee—was explicitly identified and the implications of that payment vehicle for others were also identified. Previous work had suggested that direct payment vehicles yield the most consistent results and are less prone to the bias of extraneous issues related to the payment method. The bidding sequence could be changed to incorporate different starting points and bid increments or decrements to test the sensitivity to the essentially arbitrary levels. And, additional questions could be added to test explicitly arbitrary levels. And, additional questions could be added to test explicitly for various types of strategic and information bias.

A majority of the respondents preferred the fire-free successional trajectory for the high-intensity fire site (*fig. 3*), but the preference was not unanimous (*table 1*). The decline in percentage preference for that sequence over time suggests that preference may decay further as the direct fire scars heal over time.

Table 1—*Preferences for fire-impacted and fire-free landscapes for the intense fire sequence from* figures 3 *and* 4

Picture pair	Time	Ordinal preferences	
		Burned scene	Unburned scene
		Percent	
	Intense fire sequence—near perspective		
Figure:			
3A, B	1 day	11.4	88.6
3A, C	3 years	14.3	85.7
3A, D	6 years	22.9	77.1
3A, E	12 years	30.9	70.0
	Intense fire sequence—far perspective		
Figure:			
4A, B	1 day	8.5	91.5
4A, C	12 years	8.7	91.3

The fire-free trajectory for the low-intensity fire site (*fig. 5*) was preferred by a majority of the respondents only in the immediate postfire period. Thereafter, the fire-impacted trajectory was preferred by a majority, especially 5 years after the fire and beyond. This preference switch demonstrates the need for a methodology which captures preference ratings at several points on the successional paths (*table 2*). Those results suggest that less intense fires may have beneficial economic effects on outdoor recreation, whereas intense fires may have detrimental effects.

The lack of unanimous preferences raised the further issue of how different preferences ought to be weighted. If forest resources are to be allocated efficiently, it is appropriate to weight preferences according to recreationists willingness-to-pay.

The problem of measuring preference can be characterized more formally to calculate the present discounted value of recreational activity in the fire-free trajectory and the fire-affected trajectory by the equations:

$$V_1 = \int_0^t WTP_1(t)e^{-rt}dt. \qquad (1)$$

$$V_2 = \int_0^t WTP_2(t)e^{-rt}dt \qquad (2)$$

Table 2—*Preferences for fire-impacted and fire-free landscapes for the low intensity fire sequence from* figure 5

Picture pair (figure)	Time	Ordinal preferences	
		Burned scene	Unburned scene
		Percent	
5A, E	Initial	20.3	79.7
5B, F	6 months	56.5	43.5
5E, H	5 years	89.9	10.1
5D, H	10 years	87.1	12.9

A

B

C

D

E

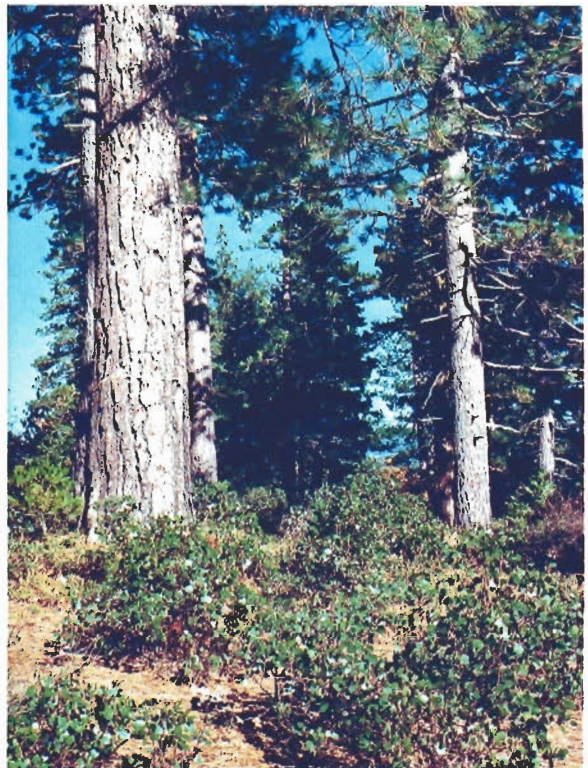
Figure 3—Changes in vegetative succession are depicted in this near perspective of a Douglas-fir climax site in Neal Canyon, central Idaho, before fire *(A)* and at varying times—1 day *(B)*, 3 years *(C)*, 6 years *(D)*, and 12 years *(E)*—after fire.

A

B

C

Figure 4—Changes in vegetative succession are depicted in this far perspective of a Douglas-fir climax site in Neal Canyon, central Idaho, before fire *(A)* and 1 day *(B)* and 12 years *(C)* after fire.



A

Figure 5—Changes in vegetative succession are depicted in a typical ponderosa pine type habitat, Sierra Nevada of California, that had *not* been affected by fire—the site when it was initially photographed *(A)*, and 6 months *(B)*, 5 years *(C)*, and 10 years *(D)* later. A similar habitat but one affected by fire is shown at the time it was initially photographed *(E)*, and 6 months *(F)*, 4 years *(G)*, and 10 years *(H)* later.

G


B


C

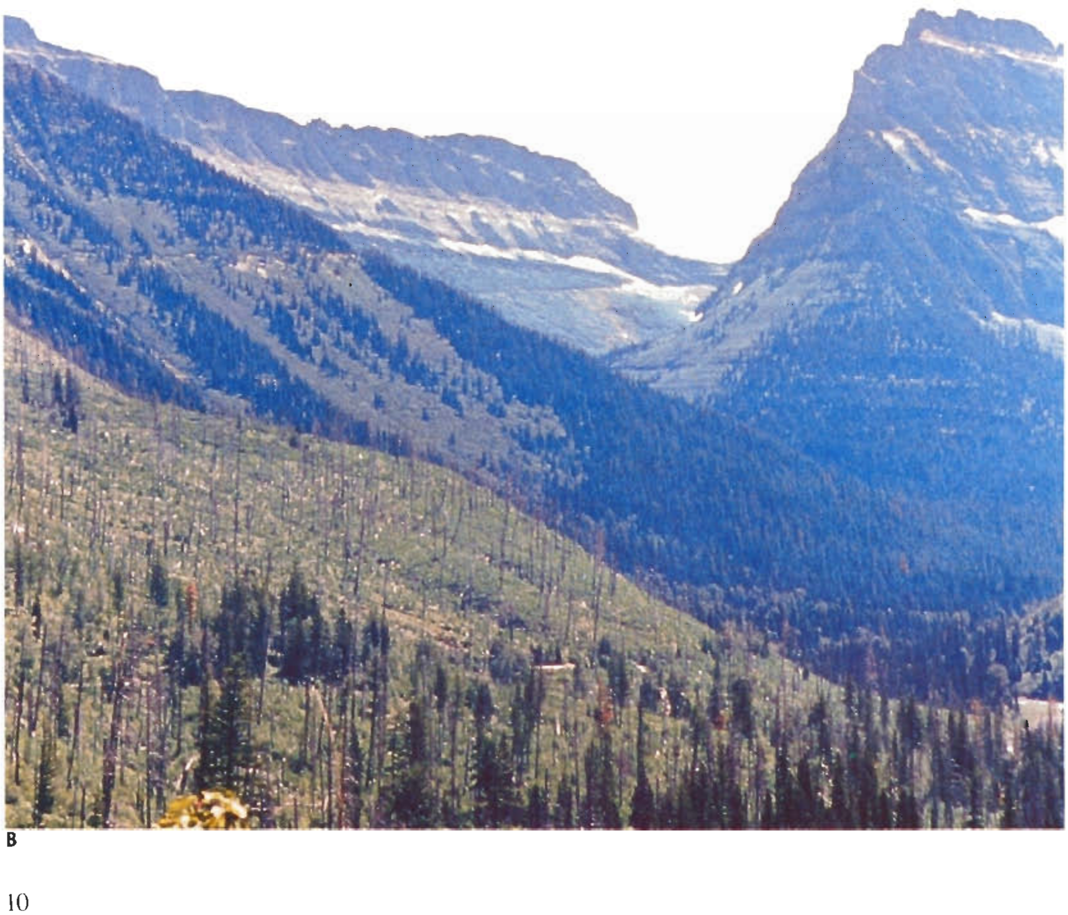

D


E


F


H

A



B

Figure 6—Scenic attributes in the Garden Wall area, Glacier National Park, Montana, have changed during the period from 1957 *(A)* to 1980 *(B)*. A major fire occurred in the area in 1967.

in which

V_1 = total present value of recreation activity in the fire free successional trajectory

V_2 = total present value of recreational activity in the fire affected successional trajectory

$WTP_1(t)$ = willingness-to-pay at time t for fire free trajectory

$WTP_2(t)$ = willingness-to-pay at time t for fire affected trajectory

r = discount rate

t = period of analysis

The net value impact of the fire can be expressed by subtracting V_2 from V_1. The result may be either positive, indicating a net "loss" in value, or negative, indicating a net "gain" in value, depending upon which trajectory is preferred.

Careful selection of the successional trajectory time intervals between preference measurements permit the willingness-to-pay functions to be approximated by linear segments within each time interval. The specification of time intervals will crucially affect the data requirements, however. If the discrete intervals are defined as $t_1 + t_2 + t_3, \ldots, t_n$ (in which $t_1 + t_2 + t_3 \ldots + t_n = T$), the additivity property permits equations 1 and 2 to be rewritten as follows:

$$V_1 = \int_0^{t_1} WTP_1(t)e^{-rt}dt + \int_{t_1}^{t_2} WTP_1(t)e^{-rt}dt + \int_{t_2}^{t_3} WTP_1(t)e^{-rt}dt + \ldots + \int_{t_{n-1}}^{t_n} WTP_1(t)e^{-rt} \quad (3)$$

$$V_2 = \int_{t_0}^{t_1} WTP_2(t)e^{-rt}dt + \int_{t_1}^{t_2} WTP_2(t)e^{-rt}dt + \int_{t_2}^{t_3} WTP_2(t)e^{-rt}dt + \ldots + \int_{t_{n-1}}^{t_n} WTP_2(t)e^{-rt}dt \quad (4)$$

The computation of willingness-to-pay requires an estimate of the total willingness-to-pay at the upper and lower bounds of integration and the appropriate interest rate. Total willingness-to-pay at any time, t, and for any trajectory, j, can be estimated by multiplying the average (sample) individual willingness-to-pay by the estimated number of recreationists in the total population that prefer that trajectory. The individual's (sample) willingness-to-pay can be obtained for a sample population, such as the study using 69 students.

The sample willingness-to-pay must be combined with estimates of the visitation rate for the site in question to obtain total willingness-to-pay as indicated in expression (5). The visitation rates must be estimated separately and should account for substitution possibilities. In forest settings where there are many substitution possibilities, it will usually be safe to assume that visitors can substitute away from less preferred sites at little, if any, additional cost. In those instances, aggregate willingness-to-pay for the preferred trajectory may be quite small. If the expense of fire damage is large or the site in question is unique, substitution will be more costly and aggregate willingness-to-pay will be correspondingly higher.

$$WTP_{jt} = \frac{\sum_{i=o}^{n_{jt}} WTP_{ijt}}{n_{jt}} \cdot N_{kt} \quad (5)$$

in which

WTP_{jt} = total population willingness-to-pay for the jth trajectory at time t

WTP_{ijt} = willingness of the ith individiual in the sample to pay for jth trajectory at time t

n_{jt} = number of individuals in the sample group bidding for jth trajectory at time t

N_{kt} = total annual visitation to the kth site or area at time t

The design of questionnaires to estimate willingness-to-pay by contingent valuation methods requires more precise characterization of consumer's surplus. Two measures of consumer surplus differ somewhat from the Marshallian measure discussed earlier (Hicks 1943). They are equivalent surplus and compensating surplus. Equivalent surplus is the payment, made or received, that brings the consumer to the subsequent level of welfare if a proposed change in the consumption of the good in question does not occur. Compensating surplus refers to the payment, made or received, to keep the consumer at his or her initial level of welfare if the proposed change does occur.

If the consumer has a "right" to the original situation, compensating surplus is the proper measure (Brookshire and others 1980). If the consumer has a right to the level of services after some change, the equivalent surplus would be the correct measure. The equivalent and compensating surpluses can be further referenced as willingness-to-pay and willingness-to-accept, depending on which reference point the consumer is entitled to.

For any given consumer, the willingness-to-pay for an increase in consumption (the compensated willingness-to-pay) will be exactly equal to his or her willingness-to-pay to avoid that reduction (the equivalent willingness-to-pay). Willingness-to-pay measures are, consequently, identical irrespective of whether they are compensating measures or equivalent measures (Randall and Stoll 1980). Willingness-to-accept measures are also identical irrespective of whether they are compensated or equivalent measures. The remaining issue, then, is whether willingness-to-accept measures differ significantly from willingness-to-pay measures.

The difference between willingness-to-pay and willingness-to-accept has been shown to be zero when there is no income effect (Randall and Stoll 1980, Willig 1976). Where income effects are present and the good is not easily divisable, the willingness-to-pay will be less than the willingness-to-accept. The difference is a function of income, the price flexibility of income, and the Marshallian surplus.

The proper measure of valuation for wildfire impacts is the surplus measure of willingness-to-pay for two reasons. First, optimizing adjustments by the consumer are not possible with respect to increments or decrements in fire control and prevention services. Measures of variation are thus inappropriate. Second, while willingness-to-accept measures may be required to value decrements in resource flows, they are not likely to be easily obtained. The difficulty lies in the absence of real markets in which such compensating payments are made and the difficulties of establishing a contingent market in which the participants will regard compensation as a realistic and proper payment vehicle. In those cases, willingness-to-accept measures should be derived from willingness-to-pay measures (Randall and Stoll 1980). The sample interview sequence described earlier was designed to elicit ordinal preferences and measure compensated surplus.

The method discussed in this section should provide a workable framework within which the economc impact of fire on outdoor recreation can be assessed and evaluated. The method relies heavily on iterative bidding procedures which emerge as the only feasible means of assessing variations in the aesthetic attributes of environment. The procedure has been designed to permit testing for strategic and information bias. Hypothetical bias cannot be eliminated so possible effects stemming from the hypothetical nature of the procedure should be addressed explicitly in the analysis.

In applying the contingent market valuation method to assess preferences and willingness-to-pay of respondents to fire-affected sites, such respondents should be drawn from the relevant segments of the recreation population. Campers, sports fishermen, and hunters are examples of such segments. The example application of the approach to the 69 students displays that such future applications are feasible.

CONCLUSIONS

Inferential techniques for measuring consumer surplus rely on the observed behavior of recreationists to infer willingness-to-pay for their recreation experience. The most prominent and widely used of these techniques is the travel-cost demand methodology. Much of the data needed to utilize this approach is readily available, but travel-cost demand methods are not sensitive enough to measure the impact of fire upon recreation. They are highly aggregative and not well suited to measure the value of specific environmental attributes. Additionally, they cannot be readily used to measure time-dependent phenomena—and the effects of fire depend on time and on the type of environmental attributes.

Contingent market valuation methods—a direct, economic approach using personal questionnaires—appear suitable for fire-impact studies. These methods do not appear to lead to biases from strategic bidding behavior and selective provision of information if the characteristics of the contingent market are explicitly defined for the potential consumer. The hypothetical nature of such markets poses a continuing problem inasmuch as there is no way to test for such biases.

The measurement of the esthetic impact of distributed forest environments uses both economic and psychological methods. The most complete economic studies employ travel cost demand methods, but they fail to deal with substitution possibilities in a realistic way, and they neglect time-dependent impacts. Psychological studies provide some insight into the structure and determinants of preferences for disturbed landscapes, but they offer little promise for measuring preferences quantitatively.

Willingness-to-pay is the appropriate measure for valuing the impact of wildfire on perceptions of recreationists. Valid willingness-to-accept measures cannot be obtained because of the absence of real markets in which compensating payments are made and because of difficulties in establishing a contingent market in which the participants will regard compensation as a realistic and proper payment vehicle.

Equivalent measures of consumer surplus are appropriate for valuing the impact of wildfire on recreation. Such measures are based on the premise that the consumer cannot make optimizing adjustments in the consumption bundle in response to incremental changes in resource flows. This premise is consistent with the conditions under which fire does, or does not occur, in that fire prevention and control services are jointly supplied and consumers cannot adjust in response to changes in the level at which those services are provided.

A contingent market valuation approach was used to value the impact of fire on recreation. Respondents in the study were asked to express their preferences to a sequence of photographs. The results suggest that less intense fires may have beneficial economic effects on recreation, whereas intense fires may have adverse effects. The impact of fire is not always negative or unanimous, and preferences among recreationists may change over time. This difference underscores the need to account for vegetative succession trajectories in assessing the impact of fire. Although the contingent market valuation approach proved suitable in this study, an assessment of the impact of fire on the perceptions of different types of recreationists is largely a statistical problem in sampling. The problem should be addressed in a formal sampling design that would be associated with efforts to test the methodology empirically.

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The Forest Service, U.S. Department of Agriculture, is responsible for Federal leadership in forestry. It carries out this role through four main activities:

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Vaux, Henry J., Jr.; Gardner, Philip D.; Mills, Thomas J. **Methods for assessing the impact of fire on forest recreation**. Gen. Tech. Rep. PSW-79. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 1984. 13 p.

Methods for assessing the impact of fire on forest recreation were studied in a literature search and an experiment. Contingent market valuation appeared the most promising. This direct, economic approach uses personal interviews and sets up a hypothetical market transaction in which values are estimated. In an illustrative application of this method, respondents were shown sequences of photographs of recreation sites depicting scenes before and after a fire. They were asked about their preferences among the scenes depicted and about their willingness-to-pay an entrance fee to the preferred sites. The example results suggest that less intense fires may have beneficial economic impacts on recreation values, whereas intense fires may have adverse effects. The valuation of the impact of fire among recreationists is not always negative or unanimous and preferences may change over time.

Retrieval terms: recreation economics, travel cost demand models, contingent market valuation, wildfire impacts, landscape attributes, wildland fire management.