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INTRODUCTION

The Nation's decision makers require information on the value of good visual air quality in order to evalute the costs of air pollution control vis-à-vis the corresponding benefits of visibility protection. The objective of this paper is to report on an experimental study designed to measure the economic value of visibility in the national parklands of the Southwest. As a basis for the study, a survey directed at the preservation of visibility issue was conducted in the summer of 1980. Over 600 households in Denver, Los Angeles, Albuquerque, and Chicago participated.

Average household willingness to pay in the form of higher electric utility bills for the preservation of the current "average" air quality and corresponding visibility in the Grand Canyon (as depicted in photograph displays) ranged from \$3.72/month in Denver to \$5.14/month in Los Angeles. These average bids increased to \$6.61 and \$9.64 per month per household in the four cities if visibility preservation were to be extended to the entire southwestern parklands region. In addition, prevention of a visible plume seen from the Grand Canyon was worth on the average between \$2.84 and \$4.25 per month for the four cities surveyed. Extrapolating these bids to the nation implies that preserving visibility in the Grand Canyon is worth approximately \$3.5 billion per year. Further, extension of visibility preservation to the entire southwestern parklands region increases these annual benefits to nearly \$6.2 billion per year.

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Finally, plume avoidance has an aggregate annual value of approximately $2 billion.

Essentially, the annual benefit estimate for the entire southwestern parklands region ($6.2 billion per year) represents the base from which benefits of power plant SO_2 controls, projected to be in place in the region in 1990, are determined. Adjusting this figure for 1990 population levels and using a real 10 percent discount rate over a 30-year power plant life yields an annualized value of $7.4 billion as the benefits of power plant SO_2 control. For comparison to these benefits, the corresponding costs of SO_2 controls are estimated to be about $3 billion per year. Therefore, on the basis of the benefit-cost analysis, the current and proposed levels of control are not without some economic justification.

In addition to examining the efficacy of power plant emissions control, this paper addresses a number of related issues. The next section provides the institutional background to these issues. Section III describes the economic basis for the study; Section IV describes the underlying foundation of utilizing photographs to represent visibility variations; and Section V presents the study design and results. Concluding remarks concerning aggregate benefit values and policy implications are offered in the last section.

INSTITUTIONAL BACKGROUND

Historically Americans have placed a high value on good visibility, that is, the ability to see distant objects clearly. Yearning for and appreciation of atmospheric visual clarity are evidenced in the country's early literature and art, including the journals of Lewis and Clark as well as the masterpieces of the great American landscape artists of the 19th century. Today that love of visibility is demonstrated not only by the millions who flock each year to our western parks, but also by the high prices paid for work by artists of the 19th century, and by the interest in Ansel Adams' simple, yet dramatically clear, black and white photographs of Yosemite National Park and other wonders of the U.S. national parks.

Over the past 100 years, Congress has acted to preserve many of our nation's natural wonders. It did so by creating and continually expanding the national parks, national wilderness areas, national monuments, national recreation areas, and wild and scenic rivers.

Since the 1950s awareness has increased that this beauty is threatened by industrial development and population growth. Pollution from coal-fired power plants became a special concern with the advent in 1963 of the first unit of the Four Corners power plant near Farmington, New Mexico. It produced a plume that could be seen clearly for scores of kilometers, reducing the clarity of the visual experience in areas of northwestern New Mexico, southeastern Utah, southwestern Colorado, and northeastern Arizona.

By the late 1960s and the early 70s, smog began to appear in Yosemite Valley on warm summer days. Confrontations developed over proposed coal-fired power plants on the Kaiparowits Plateau and near Capitol Reef National Park, both in southern Utah. The increased publicity generated magazine and newspaper articles decrying the loss of visual clarity, particularly in the western United States, and precipitated political pressures in Congress for legislative steps to protect visibility.

Increasing public concern and congressional interest in protecting visibility resulted in specific visibility provisions being included in the Clean Air Act Amendments of 1977.[1] These provisions were directed at preserving air quality conditions in national parks, national monuments, recreation areas, and wilderness areas.

The House Commerce Committee in its report accompanying the amendments to the Clean Air Act demonstrated its concern by quoting former Secretary of Interior Rogers Morton. In June, 1973, speaking of the national parklands of the Southwest, he stated:

> The scenic beauty of the rugged Southwest landscape, coupled with the clarity of the air in the vicinity, are national assets of major importance, worthy of protection for the enjoyment of future generations of Americans.
>
> Unless a policy of prevention of significant deterioration of air quality provides special protection for these national lands belonging to all Americans, their beauty may be lost forever.[2]

On December 2, 1980, the Environmental Protection Agency published regulations[3] to implement the visibility protection provisions of the Clean Air Act. Key provisions of these regulations included defining "visibility impairment" as "any humanly perceptible change in visibility (visual range, contrast, coloration) from that which would have existed under natural conditions"[4] and setting up procedures and guidelines to evaluate both existing stationary sources and new sources. The result is a long term strategy for making reasonable progress toward remedying existing visibility impairment and preventing it in the future.

Although the legislative precedent has been established, significant debate continues in regard to the efficacy of these legislative measures;

1. CLEAN AIR ACT AMENDMENT, Pub. L. No. 95-95 (August 7, 1977).
2. Environmental Protection Agency, PROTECTING VISIBILITY, an EPA report to Congress, EPA-450/5-79-008 (Oct., 1979). Report by the Committee on Interstate and Foreign Commerce, H.R. Rep. No. 95-294, 95th Cong. 1st Sess. 137.
3. 45 Fed. Reg. 80,084 (Dec. 2, 1980). 40 C.F.R. § 51 Subpart (P) (1981).
4. *Id.*

that is, do the benefits of preserving unimpaired visibility exceed the costs? This paper addresses that question.

The overall issue is the value of visibility protection compared to the costs, including air pollution control equipment and the regulatory system. Also considered is the related issue of determining the appropriate measurement techniques and visibility-related variables which describe visibility in a way consistent with human perception.

MEASURING THE ECONOMIC VALUE OF VISIBILITY

Visibility is a pure public good as described by Samuelson.[5] The primary goal of Congress in passing the Prevention of Significant Deterioration (PSD) amendments to the Clean Air Act was protection of visibility in the national parks and wilderness areas. However, industrial concerns have claimed, quite correctly, that preservation of visibility (air quality) is costly. Do the benefits of preservation justify the costs? The purpose of this section is to provide a methodology for assessing the benefits of preserving visibility so that the cost-benefit question can be answered, at least in part.

Economists have used a number of techniques for valuing public goods. One calls for direct costing, where, for example, benefits of air pollution control could be measured partly as the reduced economic damage to materials (e.g., paint coatings lasting longer), vegetation (including agriculture), and health (e.g., more productive workers). A second technique, the hedonic approach, uses an indirect method to value public goods by trying to associate changes in market prices with changes in public goods across locations. Thus, urban property value studies are typically utilized in areas of pronounced air pollution. One can obtain indication of the value people attach to clean air by examining the premium paid for homes in clean air areas. Both of these methods are described in detail by Freeman[6] and Mäler[7] but are not applicable to valuing visibility in rural recreation areas such as the national parklands of the Southwest.

In order to develop value estimates in such a situation, economists have turned to survey methods. A large literature has developed describing the use of survey techniques for valuing visibility, including early work

5. Samuelson, *The Pure Theory of Public Expenditures*, REV. ECON. AND STAT. 387 (Nov. 1954).

6. Freeman, III, *Hedonic Prices, Property Values and Measuring Environmental Benefits: A Survey of the Issues*, 81 SCANDINAVIAN J. ECON. 132 (1979).

7. K. G. MÄLER, ENVIRONMENTAL ECONOMICS (1974).

by Randall[8] and Brookshire.[9] This literature has been summarized by Schulze,[10] so great detail is not required here. However, survey techniques do indicate willingness to pay measures for air quality in an urban setting (Los Angeles) consistent with results of a hedonic property value analysis, lending support to the survey approach.[11]

Additionally, survey work with consumers has failed to show any evidence of strategic bias[12] in valuing public goods. This result agrees with the experimental work of Grether and Plott,[13] and Smith,[14] who also failed to find evidence of strategic economic behavior in experimental settings. Other biases, long recognized in the survey literature, have been identified, but standard techniques developed in the political science, psychology, and sociology survey literature have been employed to cope with them (see description of the survey procedure in Section IV).

Therefore, as the existing literature indicates, survey techniques yield reasonable estimates of individual willingness to pay for variations in public commodities. This study employed the technique, whose usefulness had been established previously, to specify how people value preservation of perceived visual air quality.

The literature in environmental economics suggests that preservation value has two possible components. First, a scenic resource such as the Grand Canyon attracts large numbers of recreators. The quality of the recreation experience depends in part on air quality, in that scenic vistas are an integral part of the Grand Canyon "experience." Thus, air quality at the Grand Canyon is valuable to recreators. We might call this value, or willingness to pay for air quality to enhance the recreation experience, user value. Thus, recreators in the national parklands of the Southwest should be willing to pay some amount to preserve air quality for each day of their own use if their recreation experience is improved by good air quality. Total annual user value is then the total number of annual

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8. Randall, Ives, & Eastman, *Bidding Games for Valuation of Aesthetic Environmental Improvements*, 1 J. ENVT'L ECON. & MGMT. 132 (1974).

9. Brookshire, Ives & Schulze, *The Valuation of Aesthetic Preferences*, 3 J. ENVT'L ECON. & MGMT. 325 (1976); Rowe, d'Arge & Brookshire, *An Experiment on the Economic Value of Visibility*, 7 J. ENVT'L ECON. & MGMT. 1 (1980); Brookshire, d'Arge, Schulze & Thayer, *Experiments in Valuing Public Goods*, 1 ADVANCES IN APPLIED MICROECONOMICS 123 (V. Smith ed. 1981).

10. Schulze, d'Arge & Brookshire, *Valuing Environmental Commodities: Some Recent Experiments*, 57 LAND ECON. 151 (1981).

11. Brookshire, Thayer, Schulze & d'Arge, *Valuing Public Goods: A Comparison of Survey and Hedonic Approaches*, 72 AMERICAN ECON. REV. 165 (1982).

12. *Supra* note 10.

13. Grether & Plott, *Economic Theory of Choice and the Preference Reversal Phenomenon*, 69 AM. ECON. REV. 623 (1979).

14. Smith, *The Principle of Unanimity and Voluntary Consent in Social Choice*, 85 J. POL. ECON. 1125 (1975).

users multiplied by the average number of days spent in the parklands by each user per year, multiplied by the average daily value to users for preserving visibility. One hypothetical market for determining user value is an increase in park entrance fees to be used to finance preservation of air quality, i.e., to purchase air pollution control equipment. Survey questionnaires can be designed to estimate use value based on such a hypothetical market.

The second component of preservation value is existence value. Individuals and households which may never visit the Grand Canyon may still value visibility there simply because they wish to preserve a national treasure. Individuals also may wish to know that the Grand Canyon retains relatively pristine air quality even on days when they are not visiting the park. Concern about preserving air quality at the Grand Canyon may be just as intense in New York or Chicago as in nearby states and communities.

The notion of pure existence value was introduced by Krutilla[15] as an outgrowth of the notion of option value developed by Weisbrod.[16] In particular, Weisbrod argued that a potential user might be willing to pay to preserve the *option* of use over a lifetime. This latter concept adjusts the concept of user value (as defined above) for uncertainty. In other words, a potential user who may never make the trip to the Grand Canyon might be willing to pay a kind of insurance premium to retain the option of future use. However, the notion of pure existence value is totally different from user or option value in that knowledge of the continued existence of a pristine national park in and of itself provides satisfaction. Thus, although option value might accrue to individuals who might never visit the Grand Canyon, that value is still based on potential use. Alternatively, existence value is not based on actual or potential use, but rather on knowledge of the continued preservation of a unique resource such as the Grand Canyon.[17]

Hence, preservation value has two additive components: user value (whether or not adjusted for uncertainty to reflect option value) and existence value. However, it is difficult to construct even a hypothetical market to capture pure existence value. Rather, one could imagine a lump sum fee added, for example, to electric power bills to preserve air quality in Grand Canyon National Park and the surrounding parklands. Such a hypothetical fee, if used as the basis of a survey questionnaire, could capture total preservation value (the sum of existence plus user value).

15. Krutilla, *Conservation Reconsidered*, 57 AM. ECON. REV. 777 (1967).

16. Weisbrod, *Collective–Consumption Services of Individual Consumption Goods*, Q. J. ECON. 78 (1967).

17. In this context existence value includes bequest value, which is the benefit derived from the assurance that future generations will have access to a preserved natural environment.

The survey described in Section IV asked approximately one-third of the respondents a pure user value question (how much would they be willing to pay in higher entrance fees per day for visibility protection at the Grand Canyon or other parks?). The other two-thirds of the respondents were asked how much they would be willing to pay, in the form of a higher monthly electric power bill, to preserve visibility in the parklands, a total preservation value question. Clearly, if total preservation value is much larger than total user value, then existence values must be large.

REPRESENTING VISIBILITY WITH PHOTOGRAPHS

Determining a visibility value for both user and existence components in economic terms requires a clear understanding of how people perceive visual air quality. This section summarizes our current understanding of the perception of visibility and presents some results on visibility perception utilizing photographs similar to those used in this study. The second part of this section describes the actual photographs used in this study.

Visibility Perception Study

Visibility is commonly interpreted as visual range or the distance an observer would have to back away from a target for it to disappear. However, visual range cannot be measured directly, nor is it necessarily representative of what an observer "sees." More importantly, visibility involves human perceptions of color and texture of near and medium distance geologic structures.

Characterization of visibility involves a selection of physical variables that can be directly measured and correlated with human perception of changes in visual air quality. Previous field experiments examined the relationships between physical parameters of visibility such as apparent target contrast, color contrast, sun angle, and human perception of changes in those parameters.[18] These studies also addressed human perceptions of changes in air quality as presented in different media, comparing observer judgments of color slides, color photographs, and the actual scene as viewed on-site.

The original study which examined these questions was conducted by the National Park Service (NPS) and Environmental Protection Agency (EPA) at Canyonlands National Park during the summer of 1979. Visitors to the Island of the Sky District of the park were asked to rate color slides

18. Malm, Leiker & Molenar, *Human Perception of Visual Air Quality*, 30 J. AIR POLLUTION CONTROL A. (Feb., 1980); Malm, Leiker, Molenar & Daniel, *Human Perception of Visual Air Quality (Uniform Haze)*, pending publication in ATMOSPHERIC ENVIRONMENT.

representing variations in air quality, sun angle, meteorological conditions, and ground cover. It was assumed, a priori, that such variables would be important factors affecting human perception of visual air quality.[19]

Studies similar to the Canyonlands study were conducted at Mesa Verde and Grand Canyon National Parks during the summer of 1980. The studies were conducted in the same manner as the Canyonlands study, with only a few differences.[20]

The results of these studies can be summarized as follows. First, a variety of perception tests indicated the existence of a linear relationship between perceived visual air quality as quantified by individuals (1 to 10 rankings of visual air quality as represented in color slides) and the scientific measure of apparent target contrast measured by a multiwave teleradiometer. Second, this close linear relationship between perception and apparent target contrast extends to perception of visibility conditions represented by 8- by 10-inch color photographs or on-site ratings.

Therefore, as these studies indicate, each visual medium (whether color slide, color photograph or on-site) yields consistent perception. Further, since photographs seem to be an acceptable surrogate for the actual scene, research based upon photographic representations is not without some justification. We next turn to a discussion of the photographs used in this study.

Photographs Used in the Study

During the summer of 1980, over 600 people in Denver, Los Angeles, Albuquerque, and Chicago were shown sets of photographs of a particular national park vista with five different levels of visual air quality. The vistas in the photographic sets were from the Grand Canyon (Trumbull, a.m. and p.m., and Desert View, a.m.), Mesa Verde, and Zion National Parks. The latter two vistas were utilized to address the issue of air quality in the Parklands Region.

These photographs were placed on display boards as full frame 8- by 10-inch textured color prints, arranged from left to right in ascending order of visual air quality with each vista a separate row. The participants were asked how much they would be willing to pay for different visibility levels as depicted in the five sets of photographs.

Participants in the survey were also asked about their willingness to pay to prevent a plume from being seen from Grand Canyon National

19. This approach may be contrasted to that of randomly sampling the joint occurrences of all of these variables and then *a posteriori* attempting to separate their effects by means of statistical regression procedures. Latimer, Daniel and Hugo, *Relationships Between Air Quality and Human Perception of Scenic Areas*, Systems Applications Incorporated, San Rafael, California, 1980.

20. For a complete discussion of the design of the two studies *see* Schulze, *The Benefits of Preserving Visibility in the National Parklands of the Southwest*, METHODS DEVELOPMENT FOR ENVIRONMENTAL CONTROL BENEFITS ASSESSMENT, Vol. 8, U.S.E.P.A., 1981.

Park. Two photographs were used, one with a dark plume in the sky and the other without a plume. The photographs were taken from Hopi firetower, Grand Canyon National Park, looking towards Mt. Trumbull. Both photographs were taken at 9 a.m. so the illumination on the canyon wall was the same. Also, both photographs had the same light high cirrus cloud layer in the sky. The plume was a narrow gray band crossing the entire vista in the sky, and in front of the top of Mt. Trumbull. The photographs were taken with a 135 mm lens on single lens reflex automatic exposure 35 mm cameras at Grand Canyon, Mesa Verde, and Zion National Parks.[21]

The five photographs for each vista were chosen so that perceptible differences existed between adjacent photographs and the middle photographs of the five would be nearest the median visibility observed during summer 1979.[22] Only the Mt. Trumbull morning series was slightly skewed, with the observed median being closer to the second photograph.

The relationship between the photographs and the regional emissions inventory constitutes the link which enables benefit-cost analysis of current and proposed air pollution controls. The primary source of future emissions will be the increase in energy related activities, including coal-mining, coal combustion to generate electricity, coal conversion to liquid and gaseous fuels, and the diverse activities of new people moving into the region.

Each of these activities creates pollutant gases and particulates, some emitted in the region and some transported into the region from similar activities upwind. This complex set of sources and pollutants was arbitrarily simplified by focusing on only coal-fired power plants, the sulfur dioxide (SO_2) they emit, and the resulting sulfate fine particulate that affects visibility. This approach is justified for this specific study region because the proposals for coal-fired power plants in the region far outweigh the proposals for other major sources of air pollution in the area.[23]

The current major sources of SO_2 in the region are listed in Table 1. All of these sources are coal-fired power plants. The size of the unit (power) is given as a range where various sources of information differ. The two sizes are sometimes the net and gross ratings, respectively. Some refer to maximum possible electrical output while others refer to the

21. These cameras were operated as part of the photographic program in the EPA/NPS regional visibility monitoring network. The network also provided teleradiometer measurements of the apparent green contrast of targets viewed from these parks, from which standard visual range, attenuation coefficient and other visibility-related variables were computed.

22. *Supra* note 18.

23. E. G. Walther & W. M. Carey, *The Occurrence of Haze, Photographed from Mesa Verde National Park Towards Hogback Mountain, New Mexico,* a report submitted to the New Mexico Health and Environment Department from the Visibility Research Center, John Muir Institute, Department of Physics, University of Nevada, Las Vegas.

TABLE 1

Current Major SO_2 Emissions in Test Region

Name	Location	Unit	Power (mw)	Sulfur Dioxide: Control (%)	Level $lb_{SO_2}/10^6BTU$	Emissions Rate (tons per day): Controlled	Uncontrolled
Cholla	Joseph City, AZ	1	110(N)–115(G)	>90[1]		7[2]–13[3]	22–40
		2	250(N)–270(G)	>90[1]		7–13	22–40
Four Corners[3]	Kirtland, NM	1	190	65		8.5–20.5	35
		2	190	65		8.5–20.5	35
		3	245	0		10–24	40
		4	778	0		90–160	160
		5	778	0		90–160	160
Hunter	Castle Dale, UT	1	400(N)–340(G)	80		7	26
(Emery)		2	400(N)–430(G)	80		35	26
Huntington[2]	Huntington, UT	1	400	80		21.5	26
		2	415	80		21.5	26
Mohave	Bullhead City, AZ	1	820	0		40, 46[3], 50[2], 64	40–64
		2	820	0		40, 46, 50, 64	40–64
Navajo	Page, AZ	1	770	0	.5216	46.7[3], 55.7[4], 81.3	46.7–81.3
		2	770	0	.5216	46.7[3], 55.7[4], 81.3	46.7–81.3
		3	770	0	.5216	46.7[3], 55.7[4], 81.3	46.7–81.3
Coronado	St. Johns, AZ	1	350(N)–395(G)	66*	.816	38	113
Reid Gardner[5]	Moapa, NV	1	110(N)–130(G)	80		16.7	83.3
		2	110(N)–130(G)	80		16.7	83.3
		3	110(N)–130(G)	80		16.7	83.3
San Juan[3]	Fruitland, NM	1	360	67	.55	22	67
		2	350	67.5	.53	21	65
		3	500	67	.55	35	106
TOTALS		23 units				692–1034	1398–1587

N = net rating = gross rating minus on site consumption of power
G = gross rating
* = .8 of total flow is controlled to 82 percent level

Sources: (1) Roberts, Edwin, 1980, phone communication to Arizona Public Service Company, June 30; (2) Christiano, John, 1980, personal communication to National Park Service, Air Quality Office, June 2; (3) Copeland, John O., 1979, EPA memo to Steve Eigsti, July 17; (4) Moon, Don, 1980, phone communication to Salt River Project, July 9; and (5) Syzedek, Laura, 1980, personal communication to Nevada Power Company, June 19.

normal output. These small differences are negligible for the purpose of this study. Each generating unit is listed separately because of the great variation of size, control equipment, and SO_2 emissions that sometimes exist between units of the same power plant. The controlled emission rate of SO_2 is reasonably well known for these sources.

A list of units proposed to be operating by 1990 appears in Table 2. The projected SO_2 emissions for these units are not so readily available. However, each utility company was requested to provide emissions information by phone or letter if no report with such information existed.

Assuming that emissions from other sources of SO_2 in the region remain constant, then the visibility impact of the power plants can be evaluated. Addition of controlled levels of 481–499 tons/day of SO_2[24] would cause an imperceptible change in apparent target contrast. This finding suggests that if the proposed power plants are controlled to the degree specified in Table 2, their emissions would have an insignificant impact on visibility. However, if both current and proposed power plants were to emit SO_2 at the maximum possible uncontrolled rate (with continued particulate emissions control), then the corresponding change in apparent contrast would be in the perceptible range.[25]

The relationship between the five levels of visibility shown in the photographs to regional emissions can be summarized as follows: (1) if all controls on SO_2 for existing power plants in the region were removed; (2) if proposed power plants (through 1990) in the region were to emit SO_2 at the maximum uncontrolled rate; (3) if existing smelter emissions were held constant; and (4) if particulate emissions remained at current levels, then visibility would decline from current average conditions (middle photographs) by *one* step to the level presented in the photographs just to the left of center. Thus, where the photographs can be described as representing "poor," "below average," "average," "above average," and "excellent" visibility, complete decontrol of SO_2 emissions by projected power plants in the region in 1990 would result in a decrease in typical summer visibility from "average" to "below average" visibility as represented in the photographs.[26] In addition, there would be a corresponding shift in the frequency of occurrence of all conditions to a generally poorer level of visibility.

The photographs collected in a regular photographic monitoring program over a period of at least six months were numerous and varied enough to provide sets for survey purposes. The apparent green contrast of the target in each photograph differed from the adjacent photographs

24. *See* Schulze, *supra* note 20.
25. *See* Malm, *supra* note 18.
26. *Id.*

TABLE 2

Major SO_2 Sources Proposed for Test Region by 1990

Name	Unit	Power (mw)	Sulfur Dioxide: Control (%)	Sulfur Dioxide: Level (pounds SO_2 per 10^6BTU)	SO_2 Emissions Rate (tons per day): Controlled	SO_2 Emissions Rate (tons per day): Uncontrolled
Harry Allen[1]	1	500	92	.17	10	129
	2	500	92	.17	10	129
	3	500	92	.17	10	129
	4	500	92	.17	10	129
Green River	—	1000	90	.2	25	250
Warner	1	250	92	.17	5	65
Valley[1]	2	250	92	.17	5	65
Garfield	1	400	90	.2	10	100
Inter-Mountain	1	750(N)–820(G)	90	.2	18–20	184–200
	2	750(N)–820(G)	90	.2	18–20	184–200
	3	750(N)–820(G)	90	.2	18–20	184–200
	4	750(N)–820(G)	90	.2	18–20	184–200
Hunter	3	400–430	90	.2	10	100–106
	4	400–430	90	.2	10	100–106
Colorado	1	250	90	.2	6	61
Cholla	3	242–289	90	.06–.07	2	20
	4	350–375	90	.07	3	30
	5	350–375	90	.07	3[2]	30
Coronado	2	350–395	66[a]	.8[3]–9	38[2,3]–43	113–127
	3	350–395	66	.8[3]–9	38[2,3]–43	113–127
Springerville	1	350	60	.6	25[2,4]	62.5
	2	350	60	.6	25[2,4]	62.5
	3	350	84	.25	10[2,4]	61
Moonlake	—	800	90	.2	20	200
San Juan	4	500	67	.55	35	106
Plains Electric	1	210	90	.2	5	50
New Mexico	1	500	80	.34	21	105
G.S.	2	500	80	.34	21	105
	3	500	80	.34	21	105
	4	500	80	.34	21	105
Reid Gardner	4	250–295	85	.14–.16	10	67
Totals	33 units	12,704–13,480	—	—	481–499	3328–3432

[a]Only 80 percent of total flow is directed through wet scrubbers with 82 percent control N = net G = gross

Sources: (1) Syzedek, Laura, 1980, personal communication to Nevada Power Company, June 19; (2) Energy Impact Associates, 1979, Update Report; (3) Moon, Don, 1980, phone communication to Salt River Project, July 9; and (4) Fleck, Lowell, 1980, phone communication to Tucson Electric Power Company, July 11.

in its subset by .02 to .12. These differences were perceptible, but they were not uniform because the photographic monitoring period wasn't long enough to produce every desired apparent contrast with the constraints of blue sky and no snow on the target. Finally, the photographs were related to regional emissions (middle photograph in each set representing "average" air quality) to provide the context for the benefits survey.[27] The next section describes the survey design and corresponding results.

SURVEY DESIGN AND RESULTS

The questionnaire was designed to address a set of issues relevant to the problem of valuing visibility in the national parklands. The national parks are unique treasures and part of our national heritage. Thus, the parks and their characteristics (e.g., visibility) might be valued by all citizens, whether or not they have or ever will visit the area. Therefore, the survey instrument elicited valuations for both actual use and existence of the parks. New and existing industrial facilities in the Southwest affect not only specific parks but potentially could contribute to a regional deterioration of visibility. As a result of this local versus regional deterioration problem, the survey instrument addressed the valuation of visibility in Grand Canyon National Park as well as in a regional scenic setting which included Mesa Verde and Zion National Parks.

Survey Design

The survey generally followed the design set forth by Randall[28] and Brookshire.[29] A hypothetical market was established around a well defined non-market good, and a bidding vehicle was utilized (entrance fee for use value and electric bill additions for existence value). Each respondent received a set of columns representing varying amounts, thus enabling him to check the appropriate bid. No initiation point for the bidding process was suggested, thus alleviating the potential for starting point bias as described in Brookshire, and empirically observed in Rowe.[30] No specific mechanisms were incorporated into the questionnaire for other bias checks since, in general, biases have not been found to be an overriding problem in surveys.[31]

27. For the calculations which form the basis of the relationship between the levels of visibility which were shown in the photographs and regional emissions, *see* chapter 3 of Schulze, *supra* note 20.

28. *See* Randall, *supra* note 8.

29. *See* Brookshire, *supra* note 9.

30. Rowe, d'Arge, & Brookshire, *supra* note 9.

31. For a summary and analysis of survey techniques in general and those exploring bias problems, *see* Schulze, *supra* note 10.

The survey began with a brief introduction explaining the causes of poor visibility and an explanation of the photographs of the Grand Canyon. The photographic sets utilized were presented to the respondents in a folding display. All respondents were shown identical displays. Some discussion of the photographs (photographic technique and specifications, air quality variation, etc.) accompanied the display.

After the introduction, past and proposed future use by the household for the Grand Canyon, Zion, Mesa Verde, Bryce Canyon, and Canyonlands national parks was determined. Two-thirds of the respondents were given the preservation value questions (user plus existence values), while one-third were given only the user value sequence of questions. At the conclusion of the valuation question, every respondent was asked a set of demographic/economic questions including home zip code, education, age group, sex, size of household, whether the respondent was the primary income earner, and income group.

After all user and preservation value bids for the Grand Canyon and region were obtained, any respondent having bid zero was asked to specify the reason. If the respondent stated confusion as to the sources and causes of air pollution or to the veracity of the photographs, a special verbal explanation was given to the respondent explaining the sources and causes of air pollution in more technical detail. A notation was made on the respondent's questionnaire if this information was requested. Finally, all respondents were shown a map of the region as a supplement to the photographic sets and verbal description.

The areas sampled by the survey teams were chosen in a semi-random fashion in that income class and racial composition were important factors in determining the sample areas. Approximately one-third of the surveys were conducted in each of the low, medium, and high income class areas.[32]

The user valuation questions asked respondents to state: (1) their willingness to pay to improve visibility in Grand Canyon National Park; (2) their willingness to pay to prevent a deterioration of visibility from the current average in the parklands region; and (3) their willingness to pay to prevent plume blight seen from Grand Canyon National Park. The payment vehicle for each of the user analyses consisted of increments in the daily park entrance fee over the existing $2.00 fee. Respondents were told to assume that all visitors would end up paying the same total daily fee and that all monies collected would be used to finance the air quality improvements represented in the photographs.

First, respondents were asked to state their willingness to pay for

32. Before the interviewing commenced, a pretest of the questionnaire was carried out in Laramie, Wyoming. This served to identify problems in the questionnaire and train the interviewing teams. Due to the size of the picture displays and possible reluctance of some respondents to be interviewed by males, male-female teams administered the surveys.

visibility improvements in the Grand Canyon, comparing the improved air quality conditions shown in Columns B, C, D, or E with the poor air quality condition in the Column A photograph. Respondents were asked to assume, when bidding, that each photograph represented the visibility on a day that he or she would be visiting Grand Canyon National Park. While the bidding for Column B versus Column A was being conducted, all other columns were covered up. The process continued for Column A versus Column C, etc. In each instance, the remaining unused columns were covered.

The second user value question was directed at determining willingness to pay to prevent a deterioration in air quality in the parklands region. After the regional picture set was described, respondents were told to assume that entrance fees would be raised not just in Grand Canyon National Park but throughout the national parklands in the Southwest in order to pay for visibility maintenance. Respondents were asked to bid on the value of preventing a deterioration from conditions represented in Column C (average) to conditions in Column B (below average), thus shifting the frequency of occurrence of all conditions to a generally poorer level of visibility in the region.

The plume analysis, which addressed visibility problems other than regional haze, constituted the final valuation question for users. The bid was in terms of an increase in the daily entrance fee for the prevention of a visible plume in Grand Canyon National Park.

The preservation value analysis varied only slightly from the user analysis. As in the user analysis, three separate issues were examined: preservation of air quality specifically in the Grand Canyon; preservation of air quality in the southwest parklands region; and the Grand Canyon plume analysis. However, in contrast to the user analysis, the preservation situations utilized an increase in monthly electric utility bills as the payment vehicle.

The focus of the Grand Canyon analysis was on the prevention of air quality deterioration from average (Column C) to below average (Column B). This analysis implicitly addressed the possibility of a shift in the frequency of occurrence of the various visibility conditions represented by Columns A through E.

The regional preservation value question also focused on a shift from the current average air quality (Column C) to below average (Column B), but utilized the *regional* photo set board.[33] A difference existed, however, between the structure of the regional user and regional preservation valuation questions. The regional user value question was a

33. Where columns A through E represented "poor," "below average," "average," "above average" and "excellent" air quality respectively.

separate bid from that for preserving visibility just in the Grand Canyon. The regional preservation was a willingness-to-pay question that asked how *much more* above the amount the respondent stated when bidding only for visibility in the Grand Canyon. Finally, the preservation value plume blight questions mirrored that of the user question except that the vehicle was an increase in electric utility bills.

Survey Results

Each of the survey subsamples has substantial similarity in gross demographic measures. Tables 3A and 3B set out characteristics of the user and preservation value respondents.[34] In general, the demographic measures bear relationships to one another which enhance their prima facie plausibility as the results of a representative survey of United States citizens.

The user value survey participants were asked to reveal the maximum incremental fee they would be willing to pay for daily admission to Grand Canyon National Park if this fee would be used to maintain specified degrees of air quality. The mean and standard deviation of responses in each city are presented in Table 4. A notable feature of these results is the uniform display of what might be called increasing returns to scale in air quality. In all three cities, nearly half of the total bid for very high visibility was an increase over only slightly diminished visibility. This finding seems to contradict the conventional assertion that incremental improvements in air quality would yield ever smaller benefits to viewers.

Instead, more serious thought must be given to what has been called the Dubos Hypothesis.[35] This argument holds that for "natural wonders," the pristine state has value, and that once any degradation has taken place, additional damage matters relatively little. The bids for air quality preservation at the Grand Canyon appear to be consistent with this hypothesis, as does the decline in the number of zero bids for greater improvements in air quality. The fact that the initial improvements were regarded as insignificant by most zero bidders is in itself noteworthy.

Visual quality at areas other than the Grand Canyon is apparently less valuable to users. Table 5 presents the mean bid of respondents to avoid a regional decrease in average air quality from situation C to B. The mean regional bid in Albuquerque was 99 cents more than the comparable Grand Canyon bid, while in Los Angeles and Denver the increases were $1.24 and $2.40, respectively. Only among Denver respondents did the

34. For a detailed discussion of the demographic characteristics of the sample, *see* Schulze, *supra* note 20.

35. The name is taken from Rene Dubos who proposed that as the environment deteriorates, people care less and less about further deterioration. In other words, people put a special value on pristine environmental conditions.

TABLE 3A

Socioeconomic Characteristics of User Value Respondent by City
(mean and standard deviation)

	Number of Respondents	*Education (years)*	*Age (years)*	*Household Size (number of members)*	*Income (× $1000)*	*Elect. Bill (dollars/month)*
Albuquerque	61	14.26	35.31	2.88	25.29	36.02
		(2.29)	(14.15)	(1.52)	(15.90)	(17.24)
Los Angeles	60	14.90	36.60	2.98	30.77	42.53
		(2.37)	(13.06)	(1.35)	(20.59)	(32.68)
Denver	45	15.02	37.11	3.09	30.14	47.67
		(2.47)	(15.36)	(1.67)	(15.89)	(26.32)

TABLE 3B

Socioeconomic Characteristics of Existence Value Respondents by City
(mean and standard deviation)

	Number of Respondents	*Education (years)*	*Age (years)*	*Household Size (number of members)*	*Income (× $1000)*	*Elect. Bill (dollars/month)*
Albuquerque	115	13.60	38.60	3.23	19.02	36.78
		(2.57)	(14.47)	(1.79)	(11.61)	(22.99)
Los Angeles	127	14.52	41.05	2.72	28.06	36.27
		(2.21)	(14.89)	(1.70)	(20.40)	(25.79)
Denver	110	14.76	40.84	2.54	30.57	58.41
		(2.34)	(14.61)	(1.41)	(20.64)	(39.79)
Chicago	96	13.94	42.84	3.80	26.12	53.91
		(2.40)	(14.71)	(1.99)	(18.28)	(36.73)

TABLE 4

Mean Bids for Specified Visibility Conditions at the Grand Canyon of User Value Respondents by City ($/visitation day)

	Air Quality Improvement**			
City	*A–B*	*A–C*	*A–D*	*A–E*
Albuquerque	1.46 (1.45)**	2.19 (1.88)	3.09 (2.32)	5.38 (4.51)
Los Angeles	2.05 (1.63)	3.53 (2.28)	4.81 (4.05)	8.79 (11.11)
Denver	1.49 (1.84)	2.53 (3.39)	3.79 (4.97)	6.33 (8.63)

*The letters A through E represent "poor," "below average," "average," "above average" and "excellent" visibility, respectively.
**Standard deviation in parentheses.

TABLE 5

Mean Regional and Plume Avoidance Bid by User Value Respondents, by City ($/visitation day)

	Bid Category	
City	*Regional Bid*	*Plume Avoidance Bid*
Albuquerque	3.16 (3.55)*	3.18 (3.26)
Los Angeles	4.77 (7.60)	4.80 (6.98)
Denver	4.93 (14.83)	4.26 (5.57)

*Standard deviations in parentheses.

surrounding region rival the Grand Canyon as a source of viewing pleasure, possibly a result of Denver residents' relatively heavy use of other parks in the region.[36]

As Table 5 also illustrates, Denver user value respondents were also exceptional in their valuation of plume blight. When asked to reveal the highest daily entrance fee they would pay to avoid seeing a plume from Grand Canyon National Park, Albuquerque and Los Angeles respondents

36. *See* Schulze, *supra* note 20.

TABLE 6

Mean Preservation Value Bids by City
($/month)

	Bid Category		
City	*Grand Canyon*	*Additional for Region*	*Plume Avoidance*
Albuquerque	4.09 (11.68)*	4.14 (14.41)	4.25 (13.42)
Los Angeles	5.14 (10.79)	4.50 (10.32)	2.84 (4.53)
Denver	3.72 (5.31)	2.89 (4.12)	2.89 (4.54)
Chicago	5.08 (12.88)	4.23 (12.47)	2.85 (8.55)

*Standard deviation in parentheses.

offered a bid that averaged very close to the bid for the maintenance of a slight haze (situation D). However, in Denver the mean plume avoidance bid was substantially higher than the bid for situation D.

Table 6 sets out the preservation value results. These bids include both a user value and pure existence value and thus would be expected to exceed a comparable user value bid. The user and preservation value portions of the survey are sufficiently distinct, warranting some discussion.

The user value bids are formulated as daily increases in entrance fees during an anticipated visit. The preservation value bids are to be paid whether or not the respondent actually uses the Grand Canyon National Park or surrounding parklands region. A user value bid comparable to preservation value bids reported would be, then, the product of the daily bid and average number of days per month the fee would be paid. Whether one uses actual visitations in the past or declared intentions, the user value will be insignificant compared to the preservation value bids reported in Table 6. The Grand Canyon bids in Table 6 are for the maintenance of situation C as the average visibility condition. If the same relationships held among preservation values for visibility as among user values, an increase in visibility to situation E would more than double these bids. This possibility arises from the consistency with the Dubos Effect which was observed among user value bids.

The preservation value of clean air in the southwest parklands region appears to be substantial to residents of all four cities surveyed, as does the avoidance of plumes. The regional bids presented in Table 6 are bids in addition to the Grand Canyon bid. In an important sense, the plume avoidance bid is also an additional bid since it addresses a separate issue.

The magnitude of these bids when compared to user value bids, especially given the large portion of the respondents who reported an intention to visit the southwest parklands region, might cause some concern regarding the true apportionment of option value and pure existence value. However, stratification of the sample suggests that visitation plans were not an overwhelming factor in determining bids and that knowledge acquired through past visits was also of relatively little importance.[37]

Also, one would have expected the preservation bids to decline with distance, and the consistency of the Chicago bids to the other bids remains a topic of interest. Further, even when adjustments are made for the income and age of respondents, distance has little discernible effect on bids to preserve air quality in the Grand Canyon.

In the next section the bid behavior described above is utilized as the basis for calculating aggregate benefit estimates for preserving visibility in the Grand Canyon and the southwest parklands region as a whole. These benefit estimates are calculated using both the southwestern states and the nation as the relevant population over which to aggregate benefits.

AGGREGATE BENEFITS OF PRESERVING VISIBILITY

The survey revealed the household's willingness to pay for preserving and/or improving visibility in specific parks of the southwest parklands region. Since the bids stated by respondents in the preservation value section of the survey encompass both pure existence value and user value, it is sufficient to focus on the preservation value section of the survey to obtain aggregate benefits estimates.

Aggregate benefits are based on estimated bid relationships obtained by applying statistical extrapolation techniques to the survey results. Hypothetically, the amount of the bids offered by interviewees to preserve visibility in the relevant national parks is a function of the independent variables of income, age, race, and distance of home from the park. Utilizing such a relationship, one can estimate the benefits to residents of the southwest parklands region as well as the entire nation resulting from the preservation of visibility in the Grand Canyon National Park and southwest parklands region.

In order to estimate the benefits of preserving visibility in national parks of the southwest parklands region (consisting of the states of California, Colorado, Arizona, Utah, Nevada, and New Mexico), three benefit functions (Grand Canyon, region, and plume avoidance) were estimated

37. For a more complete discussion of these points, *see* Schulze, *supra* note 20.

utilizing the Albuquerque, Denver, and Los Angeles data.[38] The aggregate national benefit procedure involved re-estimating the southwest benefit functions to account for the Chicago data.[39]

Given the estimated relationships one can calculate the aggregate benefits accrued to either the southwest parklands region and/or the nation from preserving visibility in the area surrounding Grand Canyon National Park. The equations indicate that if data on average family income, average age of the head of households, racial composition, and the distance to the Grand Canyon from a particular state are substituted into the equation, then the bid the state's average household would offer to preserve the visibility in the Grand Canyon area could be estimated. Aggregate statewide benefits are then determined by multiplying this figure by the number of households in the state. Following a similar procedure, one can estimate the aggregate benefits for all remaining states, and hence, the aggregate benefits to the southwest parklands region and/or the nation.[40]

38. The estimated relationships (with t-statistics in parentheses) for the Southwest are:

Bid for Preserving Visibility ($)	*Constant*	*Income ($1000)*	*Age (years)*	*Race (white = 1) (nonwhite = 0)*	*Distance (miles)*	R^2	*Number of Observations*
Grand Canyon	9.19 (4.23)	.05 (1.79)	−.14 (−4.01)	2.03 (1.69)	−.0037 (−1.2)	.06	352
Region (Grand Canyon, Mesa Verde and Zion)	18.11 (4.11)	.103 (1.79)	−.26 (−3.7)	3.69 (1.52)	−.0088 (−1.46)	.05	352
Plume blight over the Grand Canyon	8.67 (4.54)	.0014 (.06)	−.12 (−4.02)	1.03 (.97)	−.0021 (−.81)	.05	352

39. The estimated relationships (with t-statistics in parentheses) for the nation are:

Bid for Preserving Visibility ($)	*Constant*	*Income ($1000)*	*Age (years)*	*Race (white = 1) (nonwhite = 0)*	*Distance (miles)*	R^2	*Number of Observations*
Grand Canyon	7.749 (4.51)	.0447 (1.84)	−.141 (−4.37)	1.128 (1.01)	.00064 (.619)	.05	448
Region (Grand Canyon, Mesa Verde and Zion)	6.84 (3.79)	.0503 (1.96)	−.125 (−3.68)	1.13 (.96)	.00008 (.071)	.04	448
Avoidance of plume blight over the Grand Canyon	7.85 (5.61)	−.0091 (−.46)	−.118 (−4.49)	.81 (.89)	−.00016 (−.19)	.05	448

40. The following data sources were used: Number of Households: STATISTICAL ABSTRACT OF THE UNITED STATES, U.S. DEPARTMENT OF COMMERCE (1978); Incomes: *Survey of Current Business*, COUNTY AND METROPOLITAN AREA PERSONAL INCOME, vol. 59, #4 (April, 1979); Average Age and Race: CURRENT POPULATION REPORTS, POPULATION ESTIMATES AND PROJECTIONS.

TABLE 7
Annual Aggregate Benefits for the Southwest Region and the Nation from Preserving Visibility

Southwest Region Benefits for Preserving Visibility in the:	*TOTAL ($ Millions)*
Grand Canyon	466
Region—Grand Canyon, Mesa Verde and Zion National Parks	889
Avoidance of plume blight	373
National Benefits for Preserving Visibility in the:	*TOTAL ($ Millions)*
Grand Canyon	3,520
Region—Grande Canyon, Mesa Verde, and Zion	6,180
Avoidance of plume over the Grand Canyon	2,170

*Benefits for the region include benefits for the Grand Canyon.

As Table 7 indicates, the aggregate annual benefits for the parklands region from preserving visibility in Grand Canyon National Park, the encompassing region (Grand Canyon, Mesa Verde and Zion), and for avoiding plume blight seen from Grand Canyon are $466 million, $889 million, and $373 million, respectively. The corresponding national (excluding Hawaii and Alaska but including the District of Columbia) benefit estimates are also presented in Table 7.

The benefits of preserving visibility for the southwest parklands region and the nation can be related to emissions by noting that projected emissions with currently planned levels of SO_2 controls would not produce a perceivable decline in visibility in 1990 according to our calculations. However, complete decontrol of projected regional power plant emissions of SO_2 in 1990 would decrease visibility by approximately the same amount as shown in the photographs which form the basis of these benefit estimates. Thus, one can interpret the aggregate bids to preserve regional visibility as the projected benefits of power plant SO_2 controls in 1990.

The annual figures presented in Table 7 represent benefits to the southwest parklands region and the nation for preservation of visibility in 1980. In order to obtain benefit estimates for 1990 power plant controls, two modifications are required. First, the benefit figures are adjusted by the expected population growth over the next decade. The Bureau of Census estimates population growth at approximately one percent per year.[41] Second, the present value of future benefits must be calculated. Assuming a thirty year life span for power plants and real discount rates of three, six, and nine percent, Table 8 summarizes the present discounted value

41. *See* ILLUSTRATIVE PROJECTIONS OF STATE POPULATIONS BY AGE, RACE AND SEX: 1975 TO 2000, U.S. DEPARTMENT OF COMMERCE, BUREAU OF THE CENSUS (March 1979).

TABLE 8

Present Value of Future Benefits Assuming Thirty Year Life Span for Power Generating Plants (in $ Million)

Benefits to the Southwest from preserving visibility in	*Discount Rate* 3%	6%	9%
The Region—Grand Canyon, Mesa Verde and Zion National Parks	19,250	13,520	10,090
Benefits to the Nation from preserving visibility in	*Discount Rate* 3%	6%	9%
The Region—Grand Canyon, Mesa Verde and Zion National Parks	133,790	93,960	70,130

of future benefits in constant 1980 dollars to the southwest parklands region and the entire nation from preserving visibility in the parklands region.

The nine percent real discount rate case corresponds to a ten percent discount rate and a continued one percent growth in population. This case is consistent with the Office of Management and Budget discount rate guidelines (ten percent) for assessment of future benefits. Thus, the nine percent case seems the most appropriate for comparison to the associated pollution control costs. Focusing on this nine percent discount rate case and using a capital recovery factor based on a ten percent rate of interest, the relevant annualized benefits for preservation of regional visibility are $1.173 billion and $7.4 billion for the southwest parklands region and the nation, respectively.[42]

Clearly, preserving visibility in the southwest parklands region also entails certain costs. These include capital expenditures for SO_2 removal equipment, recurring annual expenditures, and the cost of the regulatory system. The capital expenditures associated with SO_2 removal for all current and proposed power plants in the region (see Tables 1 and 2 for listing) are estimated to be approximately $5.3 billion or between $270 and $560 million per year for real interest rates of three and ten percent and a 30-year power plant life.[43] In addition, the recurring annual ex-

42. The capital recovery factor is the rate which transforms an initial capital amount (present value) into a series of equivalent annual amounts, including both interest and capital.

43. *See* "Cost Analysis of Lime Based Flue Gas Desulferization Systems for New 500 Megawatt Utility Boilers," EPA document EPA-450/5-79-003 (Jan. 1979), prepared by PEDCO Environmental, Inc.

penditures are estimated to be \$2 billion per year. Finally, the regulatory system cost is approximately \$530 million per year.[44] Therefore, total costs of currently planned SO_2 controls for the region are between \$2.8 and \$3.1 billion annually (1980 dollars). Therefore, national benefits (\$7.4 billion annually) exceed the total control costs. These approximate values indicate that the currently proposed levels of control on SO_2 emissions are not without some economic justification.

Concluding Remarks

Three especially noteworthy observations emerge from the above analysis. First, contrary to conventional thinking, survey respondents place a much higher value on higher levels of visual clarity than on comparable subsequent decreases. Further, neither past nor anticipated visits to the Grand Canyon seemed to be important determinants of preservation value, and distance from the Grand Canyon had little statistical significance in explaining the magnitude of household bids.

Second, the magnitude of the annual preservation benefits when aggregated across households is impressive: \$889 million in the southwest parklands region and \$6.2 billion in the nation. The present value of these benefits over 30 years, discounted at a three percent real rate, would be \$19.2 billion and \$133 billion in the southwest parklands region and the nation, respectively.

Third, total user value alone is approximately two orders of magnitude smaller than total preservation value, suggesting a large pure existence value in this study. This finding contrasts with a recent study of the South Platte River Basin near Denver in which user value and existence value (including bequest value) were of the same magnitude.[45] Therefore, as in this study of the Grand Canyon region, existence values derived from knowledge that a *unique* natural wonder remains preserved may be very large (as opposed to a river basin for which there may exist reasonably close substitutes).

In summary, the survey results revealed that Americans place great value on the preservation of air quality in the southwest parklands region and that this value is not localized to residents in the Southwest. Further, the survey found that pure existence value overwhelms a substantial user value for the national parks in the region.

Because the Grand Canyon is the dominant feature in a region with

44. Annual regulatory system costs are taken to be equal to the entire Environmental Protection Agency budget for all air quality programs plus an equal amount for private sector costs. This is an obvious overestimate of the cost of power plant SO_2 control but more refined data were not available. *See* the Federal Budget (1981).

45. *See* Greenley, Walsh & Young, *Option Values: Empirical Evidence from a Case Study of Recreation and Water Quality,* Q. J. OF ECON. (forthcoming).

many visitor attractions, one must be especially cautious in extending these findings to other recreational attractions. Probably there are few natural phenomena in the United States about which Americans have such strong feelings. Obvious candidates for this short list would be Old Faithful (in Yellowstone National Park), Niagara Falls, and perhaps a few others.

Two qualifications are important in interpreting these results. First, the accuracy of the survey techniques used in this study to estimate the benefits of preserving visibility in the southwest parklands region can be judged by comparison to other methodologies. Such comparisons suggest that all available techniques, including survey methods, property value, wage and travel cost studies, are subject to errors. It is inherently difficult to quantify environmental values in dollar terms, but available evidence indicates that the several techniques available all yield the same order of magnitude of estimated benefits when applied to the same problem.[46]

Second, the principal benefits of preserving visibility in the Grand Canyon Region, as estimated in this study, derive from the apparent desire of Americans to preserve a national treasure, whether or not they intend to visit or use the region themselves. Economists have termed this type of value "existence value." To our knowledge, this is the first study attempting to estimate existence values per se. Thus, the methodology used in this study should be viewed as experimental.

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46. *See* Brookshire, *supra* note 13.