

DRAFT MEMORANDUM

TO: Brett Snyder, Brian Heninger, OPPE, Environmental Protection Agency
FROM: Lauraine Chestnut, Hagler Bailly Services, Inc.
DATE: April 15, 1997 (edited by EPA staff on 5/22/97)
SUBJECT: Methodology for estimating values for changes in visibility at national parks

1.0 BACKGROUND ON VALUE OF VISIBILITY AT NATIONAL PARKS

Society has long recognized that there is a value to preserving visibility. Section 169A of the Clean Air Act, added in 1977, establishes a national goal of both remedying and preventing visibility impairment in major national parks and wilderness areas caused by human activity. This memorandum presents a proposed methodology for estimating the value to the U.S. public of improvements in visibility that are expected to be achieved at national parks throughout the country as a result of proposed changes to national ambient air quality standards for particulate matter and ozone. The proposed methodology relies on previous economics research on households' willingness to pay (WTP) for improvements in visibility at national parks in the United States.

Visibility has a value to individual economic agents primarily through its effect on the viewing activities of consumers. Consumer values for changes in visual air quality can be divided into use and nonuse values. Use values are related to the direct effect on the individual's well-being from experiencing various visibility conditions. Nonuse values (also called passive use values) are the values an individual holds for protecting or improving visibility for use by others now and in the future (bequest value) and for knowing that visibility is being protected regardless of current or future human use (existence value). Option value, the value an individual holds for keeping the option available for one's own future use, might fit into either category but often goes in the passive use category.

Values for changes in visibility conditions can be further divided in terms of residential and recreational settings. Residential settings include urban, suburban, and rural areas where people live, work, and participate in everyday recreation such as ball games, walking, picnics, etc. We define recreational benefits as related to major state and federal recreational sites such as state and national parks and wilderness areas. Therefore, we define the following categories of benefits for improvements in visibility:

- ▶ Residential use values related to effects on individuals at work, home, and recreation near their homes.
- ▶ Residential nonuse values related to effects on other individuals, or purely for the sake of improved visibility.

- Recreational use values related to expected effects when one visits a major recreational site such as a national park or wilderness area.
- Recreational nonuse values related to bequest and existence values for visibility conditions at major recreational sites.

Based on available empirical literature, Chestnut and Rowe (1990a) conclude that residential use values probably account for more than half of all values for changes in visibility due to regional haze in the United States. This is because most people spend most of their work and recreation time near their homes and because of the substantial numbers of individuals affected by visibility changes in residential settings (as defined above). Chestnut and Rowe also indicate that recreational nonuse values tied to bequest and existence value motives are likely to exceed recreational on-site use values (as defined above). If a large number of individuals hold even small nonuse values for visibility at these sites, such values can exceed on-site use values when summed across the total affected population. Finally, there is insufficient empirical evidence to develop estimates of residential nonuse values, and there is little evidence to suggest that such values are significant.

For the Section 812 assessment of national benefits of the Clean Air Act, a methodology for estimating residential use values for visibility changes has already been developed. This memorandum presents a proposed methodology for supplementing the residential use value estimates with estimates of additional value to the public for visibility improvements at national parks. The methodology presented in this memorandum is similar to the methodology used by Chestnut and Dennis (1997) in an assessment of the visibility benefits at national parks in the southeastern United States from the expected Title IV SO₂ emissions reductions. This memorandum provides more background on the basis for this methodology and extends it nationwide to the extent possible based on available literature.

It is sometimes suggested that a change in visibility must be perceptible to the affected individual if he or she is to place some value on that change. Current estimates suggest that a change in visual range must be at least 10% to 20% to be perceptible to the human observer (Trijonis et al., 1990). However, it is not so obvious how small changes in visibility conditions should be treated in a benefits analysis. Some changes, especially when measured in seasonal or annual averages, may not exceed perception thresholds, and it may therefore be asserted that they have no value. This conclusion can have two problems. The first problem is whether or not a change is interpreted as perceptible may depend on the averaging time used to measure the change. It is possible that a given change in emissions could result in a perceptible change in visibility on some days and affect well-being on those days, but when these changes are averaged over a season or a year, the change appears to be below the perception threshold and may be incorrectly treated as having no value. Carson et al. (1990) found that a share of respondents to a visibility valuation survey gave positive, nonzero WTP responses for perceptible visibility improvements that would occur on only three days a year in a residential area. The second problem is that although emissions changes as a result of a single pollution control program may not cause perceptible

changes in visibility on any day, they may still contribute to perceptible visibility degradation when combined with emissions changes from other programs. The danger here is that by examining the question of visibility one program at a time we may find that no one program creates a perceptible change, but when all programs are combined the effect may be quite perceptible. We therefore recommend that each program be given credit for changes in emissions that contribute to visibility improvements, even if the change attributable to that one program is very small.

2.0 WTP ESTIMATES FOR VISIBILITY CHANGES IN NATIONAL PARKS

Chestnut and Rowe (1990a) reviewed two types of economic valuation studies that have estimated WTP for improvements in visibility in national parks. One type of study has asked visitors to parks what they would be willing to pay in additional park entrance fees for improvements in visibility conditions during their visits to the park. These studies measure only direct on-site use value and do not capture any option value or other types of passive use values. As noted in the Chestnut and Rowe review, these studies tend to find WTP values on the order of a few dollars a day for noticeable improvements in visibility conditions at scenic national parks. Because the number of days the average household spends at national parks each year is quite limited, these values sum across all affected households to relatively small amounts compared to WTP values for improvements in visibility at locations where people live.

The other type of study in which WTP has been estimated for improvements in visibility conditions at one or more national parks has asked general public respondents what they would be willing to pay in higher prices and taxes for improvements in air quality that would result in better visual air quality at specific national parks. Three studies of this type have been conducted in the United States. The first focused on the Grand Canyon and other national parks in the Southwest (Schulze et al., 1983). The second, sometimes referred to as the National Parks Visibility Values Study, covered national parks in California, the Southwest, and the Southeast (Chestnut and Rowe, 1990b; 1990c). The third focused on just the Grand Canyon (Decision Focus, 1990). These studies estimated average total preservation values for visibility improvements in national parks for all households, whether or not they have visited or plan to ever visit the parks. The estimates therefore reflect both use and nonuse values for visibility improvements.

All three of the second type of study found that total preservation values far exceed on-site use values estimated in previous studies. The WTP estimates were obtained in all three studies by asking respondents about their WTP for specific improvements in visibility at national parks, illustrated with photographs. Samples were drawn from the general population who lived near and far from the parks in question and included those who have visited the parks and those who have not. No specific mention was made in the WTP questions to use or nonuse values. The question simply described the change in visibility and asked for a WTP response. In this context, it is expected that the responses reflect values people hold for the opportunity to enjoy the improved visibility during possible future visits to the site, for others who may visit now and in the future, and just because they want visibility improved in these areas regardless of human use. Responses

to follow-up questions in the National Parks Visibility Values Study suggest that passive use motives may be significant because respondents indicated that, in giving their WTP responses, motives other than their own opportunity to enjoy the site were important. All of the studies found that many of those who had never visited, and never planned to visit, these parks still had positive values for visibility improvements at these locations. WTP values were, however, substantially higher for those who had visited or expected to visit the parks, as well as for those respondents who lived closer to the parks in question.

The National Parks Visibility Values Study addressed some important methodological issues concerning the earlier preservation values study and obtained estimates of WTP that were roughly one-third the size for a comparable change in visual range at national parks in the Southwest. The results of the National Parks Visibility Values Study were similar to the Decision Focus study results for comparable visibility change scenarios at the Grand Canyon, although the authors of the latter study felt that adjustments to the WTP results were needed that reduced the average WTP values somewhat, especially for small change in visibility.

For this assessment of national benefits of potential visibility improvements at national parks, we select the results of the National Park Visibility Values Study from which to derive a quantitative methodology. This is the only preservation value study that has covered national parks in areas other than the Southwest, and therefore provides a much broader basis for developing national estimates. There are some important limitations in the information provided by the study for the purposes of this assessment. These limitations are noted below, and alternative assumptions for addressing these limitations are proposed.

For the National Parks Visibility Values Study, a mail survey was conducted in 1988 with a sample of residents in Arizona, California, Missouri, New York, and Virginia. A total of 1647 completed responses were obtained. National parks in three regions were considered in different survey versions: California, Southwest United States, and Southeast United States. Respondents giving WTP estimates for each region were selected from a state within the region and from four states outside the region. Respondents were shown photographs illustrating four levels (current 10th, 50th, 75th, and 90th percentiles) of visibility conditions at a prominent national park in each region (Yosemite, Grand Canyon, and Shenandoah). Respondents were shown the locations of all of the Class I national parks on a map of the United States. Respondents were asked what they would be willing to pay each year per household to have average visibility conditions at all national parks in one of the regions improve from the 50th to the 75th or to the 90th percentiles, or to prevent a degradation to the 25th percentile. Respondents were asked in a follow-up question whether their WTP was entirely for visibility rather than for other park protection concerns, and, if not, what percentage was just for visibility. The average response for all regions was that about 60 percent was just for visibility. All the estimates reported here have been adjusted to reflect the responses to this follow-up question.

In addition to the three versions of the questionnaire covering each of the three regions, other versions of the questionnaire were used to address a few other questions. One of these asked

respondents their WTP for visibility improvements in all three regions. The sum of the WTP values across the three regions when valued separately was similar in magnitude to the WTP estimates for all three regions together, suggesting that the values for individual regions can be summed if more than one region is affected.

Table 1 shows the "indicator" park used for each region to illustrate the hypothesized change in visibility conditions at parks throughout the region. Table 1 lists all the Class I (a Clean Air Act designation) national parks where the National Park Service has determined that visual air quality is an important resource. Table 1 shows that although the study covered only three regions out of six, these three regions comprise about 68% of the total visitation to national parks in this category.

Analysis of the responses showed that significantly higher WTP responses were obtained from respondents who lived in the region where the parks are located or had higher household income. Responses were somewhat lower for older respondents and for male respondents. The sample had somewhat higher average household income than the national average: \$41,000 for the sample versus \$32,000 national average in 1987. Across all three regions, the estimated income elasticity of WTP for changes in visual range at national parks was approximately 0.9. Therefore, average household WTP adjusted for income is about 80% of the sample mean WTP. Average annual household WTP responses, adjusted for national average household income and put in 1990 dollars, are shown in Table 2 for each of the WTP questions. The mean household WTP values are reported separately for in-region and out-of-region residents.

After the WTP questions for visibility changes at all parks in one of the regions were asked, the survey respondents were asked what share of their WTP was for the indicator park in that region. In each case the indicator park is the one shown in the illustrations and is a prominent and frequently visited park in that region.¹ The answers were similar across the three regions and differed similarly between in-region and out-of-region residents. For all three regions, the in-region respondents said an average of 50% of their WTP was for the indicator park, and the out-of-region respondents said an average of 40% of their WTP was for the indicator park.

¹Yosemite and Grand Canyon are the most frequently visited parks in their respective regions. In the Southeast, Shenandoah visitation is lower than Great Smoky Mountains visitation, but visibility conditions at these two parks are reasonably similar.

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Table 1
Class I National Parks Where Visibility is Considered an Important Resource

Region	National Parks	Share of Total Visitation to These Parks
California	✓ Yosemite 3.7 ✓ Sequoia/Kings Canyon 1 ✓ Redwoods .4 ✓ Pinnacles .2 ✓ Lava Beds .1 Death Valley 1.2 ✓ Lassen Volcanic .4 ✓ Joshua Tree 1.2 ✓ Point Reyes 2.5	18% <i>20%</i>
Southwest	✓ Grand Canyon 4.8 ✓ Mesa Verde .6 ✓ Arches .9 ✓ Bandelier 0 ✓ Capitol Reef .6 ✓ Carlsbad Caverns .5 ✓ Bryce Canyon 1.2 ✓ Chiricahua 0 ✓ Zion 2.4 ✓ Saguaro .7 ✓ Canyonlands .4 ✓ Petrified Forest .8 ✓ Rocky Mountain 3.0	27% <i>30%</i>
Southeast	✓ Shenandoah 1.6 ✓ Great Smoky Mountains ^{4.8} ✓ Mammoth Cave 2.0 ✓ Everglades 1.0	23% <i>17%</i>
Northwest	Olympic 3.8 Craters of the Moon .2 North Cascades 0 Glacier 1.7 Mount Rainier 1.3 Yellowstone 1.4 Crater Lake .5 Grand Teton 2.7	22% ✓
Central	Theodore Roosevelt 0 Guadalupe Mountains .2 Bandlands 1.0 Big Bend .3 Wind Cave .8 Isle Royale 0 Voyageurs .2	5% ✓
Northeast	Acadia 2.8	5% ✓

Note: The National Parks Visibility Values Study obtained WTP estimates for parks in California, the Southwest, and the Southeast. The "indicator" park is shown in bold for each of these three regions. In each case the indicator park is the most frequently visited and best known park in that region.

Region	Change in annual average visual range	Mean annual WTP in-region (\$1990)	Mean annual WTP out-of-region (\$1990)
California (n=330)	90km to 125km	\$53	\$35
	90km to 150km	\$64	\$43
	90km to 45km	\$57	\$41
Southwest (n=332)	155km to 200km	\$40	\$36
	155km to 250km	\$58	\$44
	155km to 115km	\$49	\$39
Southeast (n=346)	25km to 50km	\$53	\$28
	25km to 75km	\$66	\$43
	25km to 10km	\$60	\$38
Source: Chestnut and Rowe (1990b)			

3.0 PROPOSED ASSESSMENT METHODOLOGY FOR VISUAL RANGE CHANGES AT NATIONAL PARKS

The assessment question addressed in this memorandum is how to estimate WTP for changes in visibility conditions at national parks that exist in addition to WTP for changes in visibility conditions where people live. A key uncertainty in applying the National Parks Visibility Valuation Study results to estimate values in addition to residential values, is that we do not know if there may be some overlap between WTP estimates for visibility where people live and for visibility in nearby parks. It is probably safe to assume that values held by out-of-region residents for national parks in a region can be added to values for residential visibility conditions in that region. The question then is whether values for residential visibility will reflect some or all of the value for park visibility for in-region residents. For most people, the national parks even in their own states are far enough away from their homes that they may not be thinking about visibility changes at the parks when they answer the residential visibility questions. However, some people may be well aware that visibility is a regional issue and that pollution control policies aimed at improving visibility where they live could well have region-wide effects. Because we do not know the answer to this question without further empirical research, three alternative assumptions on

this question will be used to define low, central and high values for visibility at national parks as follows:

- The low estimate is the value to out-of-region residents only, assuming that all of the value to in-region residents for visibility at parks is reflected in the residential WTP.
- The central estimate is the value to out-of-region residents applied to all residents both in and out of the park region. This assumes that the double counting of residential and park visibility values for in-region residents is reflected by the differential between in-region and out-of-region WTP values for parks.
- The high estimate is the full WTP value from the parks study added to the residential values with no adjustment for possible double counting.

Other aspects of the proposed assessment methodology based on the results of the National Parks Visibility Valuation Study include the following judgments and assumptions:

- National total annual WTP for changes in visual range at national parks can be estimated by summing the average household WTP for visibility changes at all the national parks in each of three regions. The results of the National Parks Visibility Valuation Study suggest that WTP values for each region can be summed. The chances of overstating total national WTP for visibility changes at all national parks in the United States because of summing values for individual regions is limited because only three regions of the country are included in the estimates.
- The National Parks Visibility Valuation Study asked WTP questions for the same change in visual range at all the parks in the region. Because emissions controls applied to meet the proposed federal NAAQS could have varying effects on visibility conditions in different locations, there is need to take this into account in the assessment. The results of the National Parks Visibility Valuation Study indicate that a large share of the total value for parks in a region is attributed to the indicator park shown in the photographs. To take this into account, we propose that 40% of the WTP value for all parks in a region be applied to the estimated change in annual average visual range at each of the three indicator parks. The average change in visual range at the other Class I national parks in the region would then be valued at 60% of the WTP for the region.

The WTP questions asked in the National Parks Visibility Valuation Study were for specific changes in annual average visual range at national parks. A WTP function is needed for extrapolating from these answers to other magnitude changes in annual average visual range. Chestnut and Rowe (1990a) proposed the following functional form for a WTP function for extrapolation purposes:

$$\text{HHWTP}/\text{year} = \beta_1 \times \ln(\text{VR}_2/\text{VR}_1) \quad (1)$$

where:

$HHWTP_i/\text{year}$	=	annual WTP per household in area i for visibility changes in that year
$VR1_i$	=	the starting annual average visual range
$VR2_i$	=	the annual average visual range after the change in emissions
\ln	=	natural log
β_i	=	estimated coefficient

This function implies that WTP is constant for a given percentage change in visual range and that WTP is zero when there is no change in visual range. Chestnut and Rowe (1990a) selected this function because it is simple and consistent with results of perceptions studies that suggest percentage changes in visibility measures are a good way to characterize an individual's perceptions of visual air quality; but other functional forms are also plausible. This function takes into account differences in starting and ending levels of visual range and is also consistent with the economic assumption of diminishing marginal utility for visibility enhancement.

Table 3 shows the estimated β for each region for out-of-region and in-region households estimated using Equation 1 and the mean household WTP values reported in Table 2 for out-of-region and in-region residents for parks in each of the three regions. The results in Table 3 show higher WTP per percentage change in visual range as the baseline visual range increases. This difference in WTP across the regions is plausible given the differences in the baseline visibility conditions across the regions. For example, in the Southeast parks the baseline visual range is about 25 km, so a 5% change in visual range means about a 1 km change. In the Southwest parks, the baseline visual range is 155 km so a 5% change in the Southwest parks means about an 8 km change.

The proposed methodology to estimate aggregate WTP for changes in visibility conditions at national parks is to:

- ▶ Determine VR1 and VR2 (or the percentage change in annual average visual range) at all of the national parks listed in Table 1 in California, Southwest and Southeast regions for each air quality scenario. Average the VR1 and VR2 values for the parks in each region other than the indicator parks (Yosemite, Grand Canyon, and Shenandoah).
- ▶ Estimate average annual WTP for an out-of-region household for the indicator park and for the other national parks in each region using Equation 1, the appropriate VR1 and VR2 values, and 40% of the estimated out-of-region β , and 60% of the estimated out-of-region β , respectively, reported in Table 3 for each park region.

Table 3
Summary Results for Out-of-Region Residents from the National Parks Visibility Valuation Study

Park Region	In-Region States (excluded from the in-region calculation)	Indicator Park	Estimated β^* for Out-of-Region Households (95% CI)	Annual Household WTP for 5% Change in Visual Range (out-of-region)	Estimated β^* for In-Region Households (95% CI)	Annual Household WTP for 5% Change in Visual Range (in-region)
California	California	Yosemite	73 (50 - 96)	\$3.56 (\$2.44 - \$4.68)	105 (65 - 145)	\$5.12 (\$3.17 - \$7.07)
Southwest	Arizona Nevada Utah Colorado New Mexico	Grand Canyon	110 (80 - 139)	\$5.37 (\$3.90 - \$6.78)	137 (111 - 163)	\$6.68 (\$5.42 - \$8.35)
Southeast	Delaware Maryland West Virginia Virginia Kentucky Tennessee North Carolina South Carolina Georgia Alabama Florida Mississippi	Shenandoah	40 (38 - 42)	\$1.95 (\$1.85 - \$2.05)	65 (57 - 73)	\$3.17 (\$2.78 - \$3.56)

* Estimated using Equation 1 and mean WTP values for out-of-region (or for in-region) households

- Estimate average annual WTP for an in-region household for the indicator park and for the other national parks in each region using Equation 1, the appropriate VRI and VR2 values, and 50% of the estimated in-region β , and 50% of the estimated in-region β , respectively, reported in Table 3 for each park region.
- Calculate the low, central and high national values for visibility changes at parks in each of the three regions according to the low, central, and high assumptions listed above.
- Sum the low, central, and high aggregate WTP values for each of the three park regions.

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