DEGRADED VISIBILITY AND VISITOR BEHAVIOR: THE CASE OF NEW HAMPSHIRE'S WHITE MOUNTAIN NATIONAL FOREST

John M. Halstead

Professor, Department of Resource Economics and Development, University of New Hampshire, Durham

Wendy Harper

Visiting Professor, Department of Economics, Wellesley College

L. Bruce Hill

Senior Scientist, Clean Air Task Force, Boston, Massachusetts

Abstract: The issue of visibility degradation and its impact on visitors to national parks and wilderness areas helped prompt passage of the Clean Air Act Amendments of 1977. This act required the U.S. EPA, the states, and federal land managers of national parks and wilderness areas to protect and restore visibility in these areas. Yet, as Hill et al. state (1995, p.2) AVisibility throughout the United States--especially in the Northeast--has declined substantially as human-induced regional smog conditions have become progressively worse...≅

While degraded visibility may adversely impact visitors= experiences and pose questions of health effects, it is also possible that gradually declining visibility may reduce the number of visits to a site, which could lead to negative multiplier effects on the region=s economy. Using data collected from a survey conducted in 1997 - 1998, this paper examines how (if at all) declining visibility in the White Mountain National Forest of New Hampshire has affected visitors= experiences and affected the probability of return visits. Photographs provided by the U.S. Forest Service of Mt. Jefferson, a 1,743 m peak in the Great Gulf Wilderness, were used to illustrate changes in visual range. Combining this information with data on travel costs and other trip expenditures, estimates are generated of the local economic impact of visibility degradation.

Introduction

Visibility impairment that results from human sources can be recognized as either haze or plumes. Haze is seen either in layers or uniformly, whereas plumes are recognized as emissions bands. This study focuses on uniform haze, as it is the primary cause of visibility impairment in the White Mountains.

While the Clean Air Act requires the U.S. Environmental Protection Agency, the states, and federal land managers of national parks and wilderness areas to protect and restore visibility in these areas (Latimer et al. 1983), the Act may not be achieving these goals. In this paper, we discuss the results of a survey conducted over the summers of 1997 and 1998. One of the goals of this study was to determine if visitors to the White Mountain National Forest can differentiate between varying levels of visibility; that is, can visitors consistently rank photographs with varying levels of haze in order of decreasing visibility. A second goal of the survey was to see if visitors perceive visibility as unacceptable at some common threshold. The survey discussed here is modeled after the Denver survey (Ely, 1994).

The paper is organized as follows: the first section discusses the design of the survey and sampling methods. The second section presents results of the survey. The third section discusses how degradation in visibility might translate into impacts on the region=s economy. The final section discusses extensions of this research which will more thoroughly analyze the problem.

Survey Design

The survey was designed to determine if individuals can accurately rate visibility conditions, and to estimate how they might value these changes in visibility. To accomplish this individuals were presented with a series of images of Mt. Jefferson to rate from clear to hazy and to rate as acceptable or unacceptable, based on how much haze they perceived in each photograph. Demographic information was also collected.

The photographs used in the survey were taken by an automatic visibility camera situated at 452m elevation Camp Dodge at the eastern end of the Great Gulf Wilderness, and were provided by the U.S. Forest Service. The photographs are centered on Mt. Jefferson, a 1,743m peak about 8 km due west of the camera site. Each photograph is accompanied by a measurement of optical extinction (Bext) measured using an OPTEC nephelometer, also provided by the U.S. Forest Service. Optical extinction, the physical measure of visibility, is a function of both light scattering and light absorption due to gases and particles in the air. High optical extinction indicates low visibility. Photographs depicting varying levels of visibility were generated via the WinHaze Visual Air Quality Modeler.

Surveys used in this analysis were collected at the Appalachian Mountain Club=s Pinkham Notch Visitor Center, a primary trailhead to Mt. Washington 2 miles south of the Great Gulf Wilderness Boundary. Visitors were approached and asked if they would like to complete a questionnaire regarding their opinions of air quality. Willing visitors were then assisted in taking the survey, using a lap top computer for ease of administration and data entry.

While the primary focus of the study was to compare two methods of valuation of nonmarket goods (contingent valuation and conjoint analysis) and to use these techniques to estimate the value of visibility, travel cost information was also collected. In addition to the standard information on place of origin, travel expenditures by category, and whether the White Mountains were respondents= primary destination,

the following question was asked:

> ***If there were a change in visibility in the White Mountains, (where visibility is reduced from photo A to photo B), would this reduce the number of trips you would make to the White Mountains? Please enter the number of trips (if any) you would no longer make.***

By analyzing the results of this question in conjunction with the travel cost data collected, it was possible to derive a crude estimate of how much direct reduction in travel spending would be caused by reactions to visibility degradation.

Survey Results

General demographic characteristics of the pool of survey respondents are provided in Table 1. As can be seen, respondents= tended to be considerably wealthier and better educated than the population as a whole. Total spending per trip was quite high, on average ($629); however, this figure was skewed by foreign visitors with extremely high travel costs. Travel expenditures accounted for the bulk of total spending (46.2 %), with spending on lodging (30.8 %) and food (23 %) also accounting for substantial dollar amounts.

Table 1. Characteristics of Survey Respondents

Gender	Male = 135 (34 %) Female = 70 (66 %)
Education	Some High School 6 (3 %) High School 16 (8 %) College 98 (48 %) Graduate School 85 (41 %)
Average Age	43.7 Years
Average Annual Income (Std. Deviation)	$56,501 (84,688) n = 186
Miles Traveled (Std. Deviation)	508 (800) n = 205
Travel Spending/Trip (Std. Deviation)	290.73 (844.66) n = 199
Lodging Spending/Trip (Std. Deviation)	193.91 (432.76) n= 199
Food Spending/Trip (Std. Deviation)	144.45 (393.73) n=199
Total Spending/Trip (Std. Deviation)	629.10 (1,399.80) n = 199

Examining the origin of respondents, it is clear that a majority of respondents were from outside of New Hampshire (Table 2). Over one-third of respondents traveled to the White Mountains from outside of New England or even outside of the United States. These figures help explain the large number of average miles traveled by respondents (over 500). However, less than 40 percent of respondents listed the White Mountains as their Aprimary destination.≅

Table 2. Survey Respondents= Region of Origin

Place of Origin	Number of Respondents (Percentage)	White Mountains as Primary Destination (% of Total)
New Hampshire	32 (16.1)	3.7
Other New England	90 (45.2)	14.0
Other U.S.	64 (32.2)	15.2
Non-U.S.	13 (6.5)	1.8

Visibility as a Determinant of Visitation

Degradation of visibility in natural areas such as the White Mountains can have deleterious effects on both quality of hikers= experiences and directly and immediately on hikers= health (Korrick et al. 1998), as well as portending potentially serious health and environmental effects on other areas. However, if visitors reduce or eliminate travel to an area because of visibility impairment, there will be direct and indirect economic impacts on the local and regional economies. This is particularly true in a state like New Hampshire where tourism is the second largest industry.

In this survey, the average respondent made about 17 trips/year to the White Mountains (Table 3). In response to the degradation question noted earlier, 79 respondents (39 %) noted that they would reduce their number of visits by one or more trips per year. This translates to an average of 0.91 less trips/year/visitor.

Table 3. Travel Behavior and Effects of Visibility Degradation

Average Number of Trips/Year (Std. Deviation)	17.0 (150.8) n = 203
Average Number of Trips Reduced due to Degraded Visibility (Std. Deviation)	0.91 (1.83) n = 203
Spending Reduction of Sample due to Degraded Visibility (avg. no. of Trips Reduced X Avg. Spending/Trip X Sample Size)	$116,213.64
Spending Reduction of Sample due to Degraded Visibility (avg. no. of Trips Reduced X Avg. Spending [exclusive of travel expenses]/Trip X Sample Size)	$62,505.24

In order to determine the direct economic effects of these reduced trips, one must first make the assumption that results would not be subject to hypothetical bias; that is, respondents would actually do as they stated (Mitchell and Carson, 1986). If one can accept this assumption, the data set can be used to estimate the direct financial losses due to reduced visitation caused by visibility degradation. However, before simply multiplying the total number of Areduced trips≅ by average spending per trip, it is prudent to determine if it is possible to identify specific characteristics of Areducers≅ vs. ANon-reducers≅ and thus provide a series of weights to adjust the loss estimates.

To analyze this issue, a logit model was specified of the following form:

CHANGE = *F(gender, education, age, origin, income, primary, trips/year, total spending)*

Here, *origin* refers to if the respondent came from New Hampshire, other New England, Other United States, and Outside of the United States, and *primary* is a variable equal to 1 if the White Mountains are the primary destination and 0 otherwise. The dependent variable, CHANGE, is equal to 0 if

respondents would not change their travel plans (number of trips) due to visibility degradation, and 1 if they would reduce the number of annual trips by one or more.

Unfortunately, the logit analysis did not reveal any clear patterns in the characteristics of those who would reduce trips compared with those who would not (Table 4). In fact, the only variable which was even of moderate significance (95% confidence interval) was region of origin. The sign of this variable indicated that those who travel farther to reach the White Mountains would be *less likely* to change their number of annual trips due to degraded visibility. None of the other variables explained respondents= probability of changing their behavior.

Table 4. Logit Analysis of Trip-Changing Behavior. Dependent Variable = Reduction in Number of Trips/Year to White Mountains due to Visibility Degradation

Variable	Coefficient Estimate (Standard Error)	Asymptotic t-ratio
Gender	0.11607 (.34637)	0.3351
Education	0.26830 (.25483)	1.0529
Age	0.00344 (.00457)	0.7532
Origin	-0.39174 (.22948)	-1.7071
Income	0.00000001 (0.000002)	0.4801
White Mtns. as Primary Destination	-0.01006 (0.35355)	-0.0284
Trips	-0.01674 (0.01863)	-0.8983
Total Spending	-0.00030 (0.00028)	-1.0551
Constant	-0.46771 (0.66691)	-0.7013
Log-Likelihood Function	-106.41	
Likelihood Ratio Test, 8 d.f.	9.72091	
McFadden R^2	0.044	
Number of Right Predictions/Percentage of Right Predictions	98.0/0.59756	

A pairwise correlation analysis was also of little use in discerning relationships between variables (Table 5). No pairwise correlation was greater than .4; signs were generally consistent with expectations. Specifically, distance from the White Mountains was negatively correlated with annual trips (ρ = -.274); distance was also positively correlated with trip spending (ρ = .343). Neither of these findings is particularly earth-shattering.

Table 5. Pairwise Correlation Matrix, Change Behavior Model Variables (n = 164)

	Gender	Education	Age	Origin	Income	Primary	Trips	Change	Total
Gender	1.000								
Education	0.060	1.000							
Age	0.148	0.185	1.000						
Origin	-0.026	-0.046	-0.030	1.000					
Income	0.081	-0.053	-0.019	-0.004	1.000				
Primary	-0.102	0.155	-0.070	0.113	-0.078	1.000			
Trips	-0.081	0.109	0.028	-0.274	0.051	-0.048	1.000		
Change	0.055	0.084	0.087	-0.168	0.010	-0.016	-0.015	1.000	
Total	0.053	-0.007	0.008	0.343	0.115	0.045	-0.091	-0.124	1.000

Local Economic Impact of Visibility Degradation

Given the lack of ability to characterize respondents as to their behavior with regard to visibility changes, a number of assumptions are necessary to calculate the net loss in regional spending which might occur. If one assumes that the average visitor will make .91 fewer trips per year, and will spend an average of $629.10/trip, then for this sample total direct losses to the region are

.91 X 629.1 X 203 = $116,213.64 (1)

Using more conservative figures, it might be assumed that most travel expenses noted in the survey accrue outside the region, particularly in the case of air or long auto trips. Therefore, calculating effects using the method in equation (1), excluding travel but including lodging and meals yields:

.91 X (193.91 + 144.45) X 203 = $62,505.24 (2)

Finally, since a majority of hikers noted that the White Mountains were *not* their primary destination in the area, it might be assumed that they would visit the greater region and spend their money elsewhere in the New Hampshire economy. If equation (2) is adjusted by the percentage of those listing the mountains as their Aprimary≅ destination, the impact is further reduced:

.347 X .91 X (193.91 + 144.45) X 203 = $21,689.32 (3)

Thus, the impact of a degradation in visibility will vary widely depending on the assumptions used, ranging from about $21,700 to $116,214 for the sample considered. This of course is accepting the original assumption that respondents would actually reduce their number of trips to the area.

Discussion

Results of this study show that respondents clearly state that a decrease in visual range in the White Mountains would reduce their number of visits to the mountains. While the survey attempted to focus respondents= attention strictly on visibility issues, it is possible that other Ajoint products≅ were coming into play. Depending on assumptions used, the impact of these potential trip reductions could have direct annual impacts on the local economy of from $21,700 to $116,214 stemming just from this sample.

Further Research

This paper represents the first attempt at analyzing the travel cost data collected during the survey process. There are a number of refinements and additional analyses which could shed more light on the issue of how visibility changes might affect local economies:

< While this sample was not representative of the general population, it is probably representative of hikers in the White Mountains. Using estimates of total hiking activity in the region to extrapolate would give a better indication of the total direct impact of the visibility changes hypothesized on the region.

< As collected, the spending figures noted represent only *direct* expenditures by respondents. Using these data to conduct an input-output analysis using IMPLAN would give an estimate of the *total* (direct *and* indirect) effects of changing visibility on the local economy.

< The survey presented at the Pinkham Notch site presented respondents with a range of visibility changes. In this paper, these were aggregated into a simple degraded/status quo interpretation. Future research will incorporate measures of the actual magnitude of visibility reduction faced by each respondent to test if larger decreases in visual range would have more effect on trip reductions than smaller decreases.

References

Ely, A.W., Leary, J.T., Stewart, T.R. and Ross, D.M. 1991. The establishment of the Denver visibility standard. In Proceedings, *Air and Waste Management Association*. 84th Annual Meeting, June 1991, paper 91-48.4

Hill, Bruce, George Allen, and Joan Carlson. 1995. Visibility impairment and acid aerosols in the Great Gulf and Presidential/Dry River Wilderness class I airsheds, White Mountain National Forest, New Hampshire. AMC Technical Report 95-2.

Korrick, S.A., L.M. Neas, D. W. Dockery, D.R. Gold, G.A. Allen, L.B. Hill, K.D. Kimball, B.A. Rosner, and F.E. Speiser. 1998. Effects of ozone and other pollutants on the pulmonary function of adult hikers. *Environmental Health Perspectives*. 106(2): 93-100.

Latimer, D.A., H. Hogo, D. Hearn, T. Daniel. 1983. Effects of the visual range on the beauty of national parks and wilderness area vistas in R. Rowe and L. Chestnut, Managing Air Quality and Scenic Resources at National Parks and Wilderness Areas. Westview Press, Boulder, CO.

Mitchell, R. C. and R.T. Carson. 1989. Using Surveys to Value Public Goods: The Contingent Valuation Method. Washington, D.C.: Resources for the Future.