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Research article

Valuing shifts in the distribution of visibility in national parks and wilderness areas in the United States

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ABSTRACT

Environmental regulations often have the objective of eliminating the lower tail of an index of environmental quality. That part of the distribution of environmental quality moves somewhere above a threshold and where in the original distribution it moves is a function of the control strategy chosen. This paper provides an approach for estimating the economic benefits of different distributional changes as the worst environmental conditions are removed. The proposed approach is illustrated by examining shifts in visibility at Class I visibility areas (National Parks and wilderness areas) that would occur with implementation of the U.S. Environmental Protection Agency's Regional Haze Program. In this application we show that people value shifts in the distribution of visibility and place a higher value on the removal of a low visibility day than on the addition of a high visibility day. We found that respondents would pay about $120 per year in the Southeast U.S. and about $80 per year in the Southwest U.S. for improvement programs that remove the 20% worst visibility days.

1. Introduction

Many environmental amenities are not constant and for some they are not constant over relatively short periods of time. Nowhere is this more obvious than with air pollution and visibility where an atmospheric inversion can produce conditions where large skyscrapers cannot be discerned by city residents one day and then the city's skyline becomes visible from distant suburbs the next day. A less obvious example is water quality in a river where quality can change with changes in pollution loading, ambient temperature and volume of flow. Thus, summary statistics such as average visibility or average water quality might not always be the best way to characterize environmental conditions because people may care about the distribution of quality over space or time. For example, the impact of climate change, which might include high variability in daily temperatures, may be better characterized by the number of days that would fall into particular temperature bins than the mean temperature shift. In addition, different distributions of days could have the same average temperature.

Government agencies often operationalize regulatory objectives in terms of reducing or eliminating the low quality end of the distribution of an environmental quality indicator. Examples include the U.S. Environmental Protection Agency's (USEPA) 8-h maximum threshold for ozone that can induce stricter regulatory action when the specified ozone threshold is exceeded and the maximum contaminant levels (MCLs) for different drinking-water contaminants. In valuing environmental quality improvements associated with such threshold policies it may be important to go beyond valuing the removal of low quality conditions to also consider the new distribution of environmental quality, i.e., where in the distribution does the improvement occur.

In the current paper we investigate an application based the USEPA's Regional Haze Program (*42 U.S. Code § 7491 - Visibility protection for Federal class I areas*).[1] Haze is a visibility impairment caused when the particles from air pollution emissions reduce the ability to see distant objects, and affect the clarity and color of what

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[1] "EPA's Regional Haze Program", http://www.epa.gov/airquality/visibility/program.html, accessed May 19, 2014.

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people see. The Regional Haze Program applies to visibility in 156 Class I visibility areas across the U.S., which are national parks and wilderness areas.[2] The goal of this program is to remove human-induced haze conditions occurring on the 20% of days with the lowest visibility during the year. The value the public places on removing the 20% worst visibility days may depend on the resulting visibility distribution. A change where the 20% worst days move to the highest visibility conditions is likely valued more than a change where the days have only a moderate improvement in visibility. The ability to look at the benefits of different distributional shifts becomes particularly important when there are control options that differentially shift the visibility distribution and have different regulatory costs.[3]

Estimation of the benefits of reducing haze is complex because the policy goal of removing anthropogenic haze from the 20% worst visibility days shifts the distribution of visibility over the year; actions that reduce or remove haze on the 20% worst days increases the number of days in the other 80% of the initial quality distribution. Valuing a threshold, such as removing the 20% worst days, may not be sufficient because it may matter to respondents what the distribution of visibility is after the removal of the worst days. Where do these days move in the other 80% of the initial distribution? Further, mean visibility is not a sufficient statistic for characterizing shifts in the visibility distributions as different distribution shifts can result in the same mean visibility.

Our study is the first to investigate how characteristics of shifts in the distribution of visibility conditions influence value estimates and link value estimates for those shifts to the Regional Haze Rule for Class I visibility areas. Two parallel studies were implemented to estimate values for visibility improvements in Class I visibility areas that face quite different visibility conditions; the Four Corners region in the Southwest and the Appalachian Mountains region in the Southeast. To foreshadow our results, we find that people do consider dimensions of the shift in the distribution of visibility (reductions in the number of lowest visibility days and increases in the number of highest visibility days). We also found that potential human health effects affect value estimates in both study regions, while ecological effects only affect value estimates in the Southwest region. Overall, we find that our approach is a promising way to use stated-preference methods to value changes in the distribution of visibility and to effectively control for changes in auxiliary attributes, such as human health and ecosystem effects, in benefit and cost analyses. We believe our general approach can be adapted to value other policies that effect changes in the distribution of environmental amenities or disamenities.

2. Previous visibility valuation research

While there is some literature on portraying distribution information to respondents in stated-preference surveys, this literature is rather limited and primarily occurs in the valuation of changes in risks. Some have used risk ladders that portray changes in thresholds of risk (Corso et al., 2001), while others have used risk cards that portray the chance in 100 that an event will occur (Krupnick et al., 2002). These approaches present changes in probabilities for binary outcomes, risk outcomes that occur or not, and are not directly transferable to valuing changes in the distribution of visibility where the change involves a continuous variable.

2.1. Previous visibility valuation studies

There have been a small number of previous studies that investigated the value of visibility improvements, and we will focus on the two most recent studies (Chestnut and Rowe, 1990; Smith et al., 2005), which are the only studies that provide value estimates for visibility improvements in Class I visibility regions (Table 1). We will refer to these as the Chestnut and the Smith studies for expositional convenience hereafter. The report from the Chestnut study, in addition to documenting their own study, provided an overview of other visibility valuation studies conducted prior to 1990.[4]

Portraying changes in visibility to respondents in a stated-preference survey is a challenging task. Respondents must be presented with the current and improved visibility conditions. Further, there is not a unique visibility improvement outcome; the worst visibility days, when improved, can be spread across the remaining distribution of days. Thus, it is a complicated design issue to consider what dimension of the distribution shift to present in a survey and how this information should be presented. The Chestnut and Smith studies used sets of four photographs to convey visibility under different conditions during the summer months. The Chestnut study estimated values for visibility improvements in Class 1 areas in California, the Southwest and the Southeast and their photographs were of scenes in Yosemite, Grand Canyon and Shenandoah National Parks, respectively (the California treatment is excluded from Table 1 as it is not comparable to the Smith study and the current study). The photographs represented 15%, 20%, 40% and 25% of summer days (Table 1). The Smith study replicated the Chestnut study using four photographs to depict the same categories of visibility conditions.

While the Chestnut study used words, as shown in Table 1, to describe the initial distributions of visibility days, the Smith study, in addition to replicating the Chestnut study, had a treatment where they used a histogram (Fig. 1) to present the number and percentage of days in each category of the initial visibility distribution. They also added a category for bad weather days, 12 days (~10%). Both the Chestnut and Smith studies asked respondents to value improvements in average visibility conditions, with average visibility improving from conditions shown in photograph C to B and C to A, as well as to prevent a decline in average visibility from C to D (see Table 1 and Fig. 1).

A key difference between the Chestnut and Smith studies is that Chestnut used different photographs that approximated the visibility conditions in each category (A, B, C and D), while Smith used a single photograph that was digitally manipulated to portray actual mean visibility condition within each category.

Neither the Chestnut study nor the Smith study explicitly controlled for factors that could confound estimates of value for visibility improvements such as concerns about effects on human health and ecosystems. For example, the USEPA (2010) states:

> *"Air pollution can affect our health in many ways. Numerous scientific studies have linked air pollution to a variety of health*

[2] "List of 156 Mandatory Class I Federal Areas", http://www.epa.gov/airquality/visibility/class1.html, accessed May 19, 2014.

[3] Most control policies and nonmarket valuation applications have been aimed at delivering overall improvements. There are some key policy exceptions that affect the spatial and temporal distribution of pollution. One example is the reformulation of gasoline in the summer to reduce ozone (Auffhammer and Kellogg, 2011). There have also been some efforts to get people to voluntarily reduce driving when it is predicted that a threshold standard will be violated (Cutter and Neidell, 2009). Cropper et al. (2014) look at the implications of a plan that would require drivers to buy special permits in advance to use their vehicles on high ozone days.

[4] Two studies were initiated that would have valued visibility in Class I visibility regions, but values were never estimated, the studies never progressed beyond the initial design stages (Balson et al., 1990; Carson et al., 1990).