Charles
River
Associates

Draft Final Report

BENEFITS OF PRESERVING CULTURAL MATERIALS FROM DAMAGES ASSOCIATED WITH ACIDIC DEPOSITION

Prepared for

The Benefits Staff
The Office of Policy Analysis
Environmental Protection Agency
Washington, D.C.

CRA Report No. 700.29

Prepared by

Charles River Associates Incorporated
200 Clarendon Street
Boston, Massachusetts 02116

December 1983

CRA

DISCLAIMER

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

AN EVALUATION OF ECONOMIC METHODOLOGIES FOR USE IN ESTIMATING THE BENEFITS OF AVOIDING AIR POLLUTANT DAMAGES TO CULTURAL MATERIALS

EXECUTIVE SUMMARY

Air pollutants, especially acidic and particulate deposition, are contributing to the erosion and soiling of a wide variety of cultural and historical structures. For this report, Charles River Associates (CRA), assisted by the Society for the Preservation of New England Antiquities, evaluated the applicability of various economic benefit methodologies to quantification of these damages. Benefit case studies were conducted to quantify the damages to outdoor art, historic buildings, and gravestones in Massachusetts. From these case studies, we have concluded that two methodologies are most appropriate for estimating the benefits of avoiding air pollutant damages:

- Where preventive maintenance and reconstruction are feasible and willingness to pay such costs is demonstrated, factor cost approaches that estimate the cost of avoiding air pollutant damage are appropriate.

- Where preventive maintenance and reconstruction costs are not feasible and damage is irreversible, or where the costs of avoiding damages exceed the benefits, contingent valuation approaches that estimate the willingness to pay to avoid air pollutant damages are appropriate.

To facilitate the estimation of benefits in the case studies, certain assumptions regarding rates of damage were required. The relationship between acid deposition or pH and erosion of materials is understood imperfectly. Consequently, convenient assumptions about the effects of reduced deposition, such as the doubling of material lifetimes, were made to permit trial calculations of benefits.

Questions added to a survey by a preservationist group in Boston revealed a total willingness to pay of between $0 and $9 per household to preserve historic graveyards, historic buildings, and outdoor art. The average for the small sample of 31 respondents was about $9, but the median was $0. Partitioning the sample into two groups, zero and non-zero willingness to pay, and recombining the medians of the two subsamples suggest an annual willingness to pay per household of about $5.65, of which about $1.30 is for historic graveyards, $2.90 for historic buildings, and $1.45 for outdoor art. In addition, respondents indicated an annual willingness to pay of about $0.70 to preserve and protect private ancestral gravestones..

A statewide survey of all bronze outdoor art objects by the Massachusetts Department of Environmental Quality Engineering yielded an estimated total of 340 objects. The cost of restoring and maintaining these commemorative and decorative bronzes amounts to about $600,000 per year, which would require an annual willingness to pay of $0.30 per Massachusetts household. If we omit restoration as a sunk cost that represents damages already incurred, the annual maintenance cost to avoid future damage from air pollutants amounts to even less, about $400,000 per year. These maintenance costs are relatively insensitive to incremental changes in pH and could be avoided only if acid deposition were reduced to minimal levels.

An analysis of air pollutant-related damages to a sample of 117 properties on the Massachusetts Register of Historic Places yielded a total cost of about $4.7 million for cleaning, reconstruction, and replacement of brick, marble, brownstone, granite, and copper materials. If a reduction in air pollutant emissions were to cause material lifetimes and intervals between maintenance to double, the present value benefit to all 6,000 properties on the Massachusetts Register would amount to about $50 million, or about $5 million per year using a 10 percent discount rate and an infinite lifetime.

Finally, a travel cost analysis of visitors to the Stockbridge, Massachusetts, workshop of sculptor Daniel Chester French yielded an estimated consumer surplus benefit to visitors (users) of about $31,0OO to preserve the entire site (from total loss). This represents a benefit of about $3 per visitor household. However, only a few of the art objects are displayed outdoors, and therefore this site value overestimates any benefit from reducing air pollutant damages. Moreover, to the extent that damages to outdoor bronzes can be avoided by lower maintenance costs, the travel cost approach is inappropriate for estimating the benefits of avoiding damages caused by acid deposition and other air pollutants.

1

APPROPRIATE METHODOLOGIES FOR VALUING THE BENEFITS OF AVOIDING ACID DEPOSITION EFFECTS ON CULTURAL HISTORICAL STRUCTURE

Economic benefit methodologies generally fall into two categories: those that use data from actual market behavior, and those that use data from surveys of intended market behavior. Actual market data are usually preferred, but such data may not always be available in cases where public goods are damaged by environmental pollutants. The object of this discussion is to evaluate the appropriateness of the economic methodologies available for use in quantifying the benefits of mitigating acid deposition effects on historic buildings, outdoor art, and private markers and monuments, particularly gravestones.

THEORETICAL FRAMEWORK

At the individual level, benefits are equivalent to the value of losses or damages avoided. If reducing the acidic effects of wet and dry deposition permits a building owner to reduce maintenance expenditures on the preservation of artistic facades, those savings represent the benefit of reducing acid deposition rates. If no maintenance is possible, then the sum discounted value of that loss over time is the benefit of implementing air pollutant controls.*

---

*What rate, if any, to discount irreplaceable assets is the subject of disagreement among economists. Where the value of an object is embodied in the skill of the individual artist, no reallocation of resources from current to future use can increase utility. Economists have argued that, in such circumstances, discounting future losses is incorrect.

Figure 1

**CONSUMER SURPLUS BENEFITS:
THE CASE OF CONSTANT COSTS**

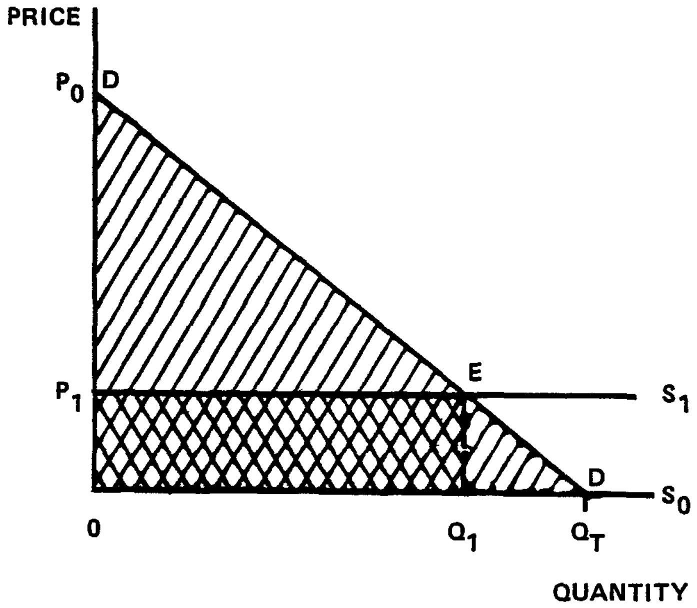
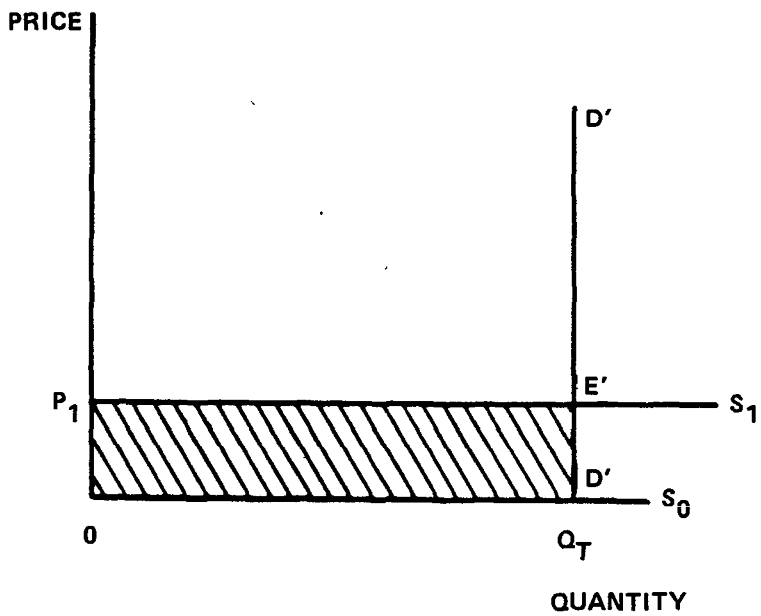


Figure 2

**CONSUMER SURPLUS BENEFITS:
THE CASE OF PERFECTLY INELASTIC DEMAND**



Measurement of total benefits requires knowledge of the willingness of all individuals to pay or incur costs to avoid some damage.* Market data reveal how much was actually paid. Such expenditures represent a true measure of benefits only when the benefits of taking action exceed the costs. Where costs of avoiding the damage exceed the benefits, as is likely to be the case for some decision-makers in the market, no expenditure will be incurred, though benefits are non-zero. In such cases, market data on actual expenditures will underestimate the benefits.

Figure 1 is useful in explaining the measurement of benefits as the value of damages avoided. For our purposes, let us assume that acid deposition causes calcareous stones used in buildings, monuments, and the like to erode so that facades are worn away in 50 years, as opposed to 500 years in a non-acidic environment. The present values of the maintenance costs to remedy this damage are S_1 and S_0, where S_0 is effectively zero given a positive discount rate. Both S_1 and S_0 are drawn horizontally to the x-axis, which means that additional facades can be maintained at the same constant cost.** The demand to maintain stone structures is represented by DD. In the absence of acid deposition damage at S_0, a total of Q_T structures will be maintained, and net benefits are equal to the shaded area under the demand curve (0 P_0 Q_T), which is commonly known as the consumer surplus. Where acidic effects require expenditures of S_1 to mitigate damages, only Q_1 facades will be maintained. Thus, the loss in consumer surplus is equivalent to the maintenance expenditures incurred in the crosshatched rectangle (0 Q_1 E P_1) plus the triangle (Q_1 Q_T E), which are due to the Q_T - Q_1 buildings whose facades are not replaced.

If the demand curve, D'D', were redrawn vertically as in Figure 2, then the benefit of maintaining all the facades, Q_T, would exceed the costs and all facades would be maintained. Under these circumstances, the expenditures on maintenance, the expenditure rectangle (0 Q_T E' P_1), would just equal the loss in consumer surplus, and the sum of all maintenance costs over all structures would provide an accurate benefit measure of damages avoided.

Formal benefit/cost analysis requires knowledge of three important linkages: emissions/acid deposition, acidity/rate of materials damage, and materials damage/human response and valuation. It is the final linkage between rate of materials damage and human response that economic benefit methodologies are

---

*Willingness to pay to avoid a reduction in utility yields an equivalent variation measure of benefits.

**The assumption of constant costs for maintaining and preserving stone and metal surfaces from acid rain damage is probably reasonable, although the quantity Q_0 is probably better measured in terms of surface area than in number of discrete objects.

designed to measure. Given a rate of erosion of carving on a marble surface, what is the human response? Are these responses reflected in some action that leaves a trail in the market, such as costs of maintenance activities or travel to a site, or are there important human responses that reflect value in a non-use context?

Stone monuments and structures are likely to be affected by acid deposition in a way that reduces their artistic or historic value. Such damage clearly affects those users whose utility is directly associated with visits to outdoor art objects, buildings, or cemeteries. These use values can be quantified by methods that rely on data from users' actions, such as travel costs to visit a site. For some objects for which there are few comparable substitutes, there may be significant non-use benefits. Some outdoor art objects by famous sculptors or architects may qualify, along with specified grave sites.

Bequest values are likely to represent an important type of non-use values. A person may have no interest in visiting the cemetery where his ancestors are buried, but he may feel obligated to take action to insure that his children and grandchildren can identify the gravestones of their ancestors if they so desire. To the extent that non-use benefits need to be considered explicitly, only contingent valuation survey methods are available to quantify such values, since by definition non-use values are unrelated to any market data or visits.

Several methodologies are available to measure the benefits of avoiding acid rain damage. The values of some environmental amenities to users are reflected in differential property values. Property with a view sells for a higher price than property without a view. It is possible that property with a view or in proximity to outdoor art or historic buildings may have more value than equivalent properties elsewhere. Similarly, more famous art objects and historic sites attract more visitors from a wider area than do less famous objects and sites, and data on visitors' travel and time costs can be used to compute the value of a site. In addition, where maintenance, reconstruction, or replacement are possible, data on actual expenditures can provide an estimate of damages avoided by acid rain controls. Finally, contingent valuation surveys can be formulated to elicit direct responses regarding willingness to pay in both use and non-use contexts.

The decision on which of the available methodologies to use in estimating benefits depends on the factors and assumptions discussed above. These include:

- Availability and dissemination of information on damages resulting from acid rain;
- Potential to avert damages through maintenance procedures or through reconstruction or replacement;
- Shape of the demand or willingness-to-pay curve; and
- Availability of comparable substitutes and importance of non-use benefits.

In subsequent sections, we consider the most appropriate methodologies to employ in quantifying acid deposition damages to the different types of metals and stones used in cultural and historical monuments, art objects, and buildings.

CEMETERY GRAVESTONES

Cemeteries contain tens of millions of private monuments and markers across the United States. Early monuments were made of slate. Marble and sandstone were also popular until the early 1900s. Since about 1930, most gravestones have been granite, a harder stone that is more resistant to erosive forces. Softer marble tends to erode at a rate of about 1 to 10 millimeters per century, so that in areas of high rates of acid deposition, the inscriptions on many older stones are becoming difficult to read.* The problem, however, is not widely recognized, and experts disagree on the efficacy of maintenance procedures. To date, few individuals have taken any action to protect or replace stones or markers.

In a market with perfect information, market demand is an accurate indicator of the value of goods and services. Under such circumstances, the appropriate procedure for valuing the benefits of preserving gravestones would be to gather data on maintenance expenditures at a representative sample of cemeteries and to estimate a demand function at a point in time for such services:

$$Q_C = f\ (P_C, I_C)$$

where Q_C is quantity of stones maintained at each cemetery;
P_C is price or cost per year for protecting stones; and
I_C is a vector of average socioeconomic characteristics of individuals who purchase maintenance services at each cemetery.

In an equilibrium market with perfect knowledge, a cross-sectional regression analysis could be applied to estimate the demand function. The consumer surplus could then be quantified to yield a measure of benefits and extrapolated to include all cemeteries.

Such a market-based econometric analysis is inappropriate when we relax the assumption of perfect knowledge. It is quite possible that people would be willing to undertake such maintenance costs if they knew the extent of the problem and were assured of the efficacy of a particular maintenance procedure. The communication of such information requires a survey context.

---

*The rate of erosion depends on many factors besides pH of rainfall, especially the compass exposure to rain and wind. Also, erosion is most rapid on edges where water and dirt collect.

Contingent valuation methods all allow the control of information presented to respondents in the survey design. Variations on the contingent bidding or direct question methods can encompass anchored and unanchored estimates, with the anchor an approximate range of costs for preventive maintenance services. Contingent ranking alternatives can be structured around choice of maintenance or replacement scenarios: $10 per acid-resistant coating application every three years vs. an immediate $200 payment to recarve the inscription if it is no longer readable.

The problem of valuing gravestones may include both a direct (user) and an indirect (non-user) component. For direct descendants of a particular ancestor whose monument is eroding, there may be value in preserving or replacing the stone. In addition, with regard to public cemeteries in small towns and private cemeteries, especially those connected with a church or synagogue, the current generation may value preserving their historic record and aesthetic appearance. The latter value is more straightforward in a survey context than the former, since it requires only a random sample of members of a particular community or congregation.

These are two problems in establishing direct value for descendants several generations removed. First, it is difficult, if not impossible, to locate all the living relatives of a particular person who died before 1930. Ideally, if those descendants could be identified they could be surveyed, but each living descendant might be similarly expected to have a number of other deceased ancestors whose gravestones might also be threatened if quarried from marble or sandstone. Thus, the problem of overlapping concerns and responsibilities of the current generation makes it difficult to select an appropriate sample. An average adult age 40 today might be expected to have parents alive, age 70, two sets of grandparents who died about 1950, four sets of great-grandparents who died about 1930, and eight sets of great-great-grandparents who died about 1900. Given immigration patterns, of course, many of those ancestors lived and are buried abroad. In addition, many deceased are likely to be buried either under granite stones that are relatively impervious to acid deposition effects, or in places less affected by acid deposition.

In this preliminary effort, we propose to focus our sampling on people rather than gravestones. That is, we will survey households to ask questions in both user (direct descendant) and non-user (steward) contexts. In this way we hope to be able to separate these benefit components.

HISTORIC BUILDING FACADES

Many of the buildings that comprise our architectural heritage have carved stone facades that are subject to damage by acid deposition. Traditional brownstone, limestone, and marble facades are subject to greatly increased erosion in acidified environments. The primary damage is to the artistic detail and carving on these historic buildings.

How to measure this loss is a difficult economic problem. The primary benefit appears to accrue primarily to users or visitors, since non-use benefits are likely to be small where there are possible substitutes. However, it is not clear whether these benefits accrue mainly to owners of such property, and are reflected in selling prices, or whether they accrue primarily to urban users in an aesthetic sense. At present, no perfectly-successful preventive maintenance procedures exist. Periodic cleaning helps to remove sulfate crusts but does not prevent the loss of material. In addition to cleaning costs, the only market data available are reconstruction costs and property values.

The reconstruction cost approach simply values damage as the cost of restoring the structure to its former condition, and uses actual data on frequency of restorations to aggregate damages across structures. This reconstruction cost approach provides a minimum estimate of the damage. 'Where recognizable damage occurs but no reconstruction is undertaken, it is clear that the benefits of reconstruction are insufficient to compensate for the costs. Nevertheless, it is unlikely that the benefits of reconstruction are zero. Therefore, using reconstruction costs as a basis for assessing damages avoided fails to include properties where damages were incurred but costs exceeded benefits, thus precluding reconstruction.

Property value methods are available to measure the full consumer surplus benefits of avoiding or mitigating acid deposition damages, but they employ data and assumptions that may not be appropriate to measurement of aesthetic values. Property value methods use a hedonic regression procedure to estimate the contribution of a particular attribute of the property to its sale price. The problem of valuing facades is that some buyers, especially commercial buyers, may be little concerned with aesthetics, and selling prices may reflect only the utility value and structural condition of a building. If this is the case, then property value techniques will yield no value for the aesthetic resource embodied in the facade. Even if property values do reflect aesthetic values, the data available on a sale may not provide enough detail to control for the myriad attributes of the structure, land, and location so as to permit a correct specification. The data requirements for property value studies are extensive and demand a dataset detailed enough to control for the effects of each city, style of building, and the condition of the facade as distinct from the structure. These practical requirements persuade us that the hedonic regression approach is unlikely to yield meaningful results. The collection of such a dataset world represent quite a costly enterprise, promising little likelihood of obtaining reliable benefit estimates.

A lower-cost variant of the hedonic property value approach is to focus on comparables in the appraisal sense. Appraisers compare properties that are similar in all respects but the type and condition of the facades. By comparing properties with and without artistic facades while holding other features constant, it is possible to derive an approximation of the value of a specific property characteristic. Given sufficient data, it is possible to estimate values using a hedonic estimation procedure, but in the absence of such a dataset, the comparables approach may yield a reasonable estimate of the value of a facade based on property values. The cornparables approach seems applicable to certain common styles of structures, such as brownstones, where a number of comparable individual properties can be identified. For more singular structures, there may be no comparable edifice nearby or even in the same city for use in an appraisal comparison.

One other viable approach is the contingent- valuation survey method. This technique elicits information on each respondent's willingness to pay for a specific good or service by asking a direct question. Whereas the property value approach is based on the belief that the value of the facade is embodied in market transactions between private buyers and sellers, the contingent valuation approach attempts to estimate aesthetic benefits to third parties by asking respondents to value them with respect to a direct question.

The concept of facade easements may provide a realistic context within which to structure a direct question survey. Public trusts have solicited donations to purchase easements to restore the condition and ensure the continuity of facades of architectural and artistic merit. Where willingness to pay is tied to an easement on a particular building or group of buildings, the total represents a consumer surplus estimate of the facade's value to the public. The easement context allows for private individuals purchasing the rights to the facade without confronting biases inherent in public support for private property.

Implementation of a contingent valuation survey in the context of willingness to pay for facade easements, however, could be quite difficult. The concept of easements is not widely understood, nor is the average person easily able to make comparisons without recourse to detailed slides or photographs. Nevertheless, such a survey appears to be the only method that will yield a theoretically-correct consumer surplus measure of benefits. Moreover, the contingent valuation questionnaire and sampling design can be structured in such a way to capture any non-use benefits that may prove important in valuing certain facades.

OUTDOOR ART

There are numerous examples of outdoor art that provide decoration and cultural interest for our urban and rural landscapes. They range from well-known statuary created by famous sculptors, such as Daniel Chester French's statue of Lincoln in the Lincoln Memorial, to more common commemorative statues, usually cast from bronze or copper on a marble or other stone base. In addition, The General Services Administration has recently funded the creation of a considerable amount of public art to decorate federal buildings. It is this wide diversity of outdoor art that makes any benefit assessment difficult.

Methods that can be used to quantify the benefits of a famous work of art are not necessarily suitable for valuing the more commonplace war memorials found in many communities large and small. Where visitors come to enjoy a particular statue or site, the expenditures on travel and time can be used to approximate a demand curve using the Clawson-Knetch travel cost methodology. This methodology provides an estimate of the total value of the site or statue to visitors; it is useful primarily for measuring benefits in situations where acid rain damages result in irreparable loss of a statue or art object; When visitors have multiple destinations, as is often the case in urban areas where large numbers of cultural and outdoor art sites are located, it is difficult to apportion the time cost of the trip to a specific site visit. The problem is similar to apportioning fixed costs across multiple product lines.

Even more troublesome from an analytic point of view are sites that combine outdoor art and history. Travel cost methods can utilize data on visitation to estimate the value of the Gettysburg battlefield, but they cannot segregate the value of the commemorative art and gravestones from the historical significance of the site. Unfortunately, much outdoor art is placed in sites whose value is historical as well as cultural.

Where preventive maintenance or replacement is possible, as is likely for most war memorials, an approach that uses the cost of averting behavior is applicable. A major source of damage from brass and bronze statues is leaching of the metal and subsequent staining of what is often a marble base. A number of maintenance procedures are being tested to prevent this erosion and staining, and the application of various coatings protected by waxing twice a year appears very promising. Erosion of inscriptions in marble or other stone is also common, and the costs of replacement can be estimated. If we can assume that the public is committed to maintaining these statues (the demand curve is vertical in the relevant price range, as shown in Figure 2), then any incremental maintenance and replacement costs necessitated by acid deposition provide an accurate estimate of those damages to art work.

Contingent valuation surveys are applicable both to unique works of art and to more common war memorials and other commemorative statuary. Willingness-to-pay surveys reflect total consumer surplus benefits. However, if maintenance and replacement are possible without loss of some artistic value inherent in the creator of the statue, and if the public benefit exceeds the maintenance costs, then the expenditures for regular maintenance represent a measure of the benefits attributable to damages avoided. In the case of a truly unique work of art that cannot be maintained or replaced, measuring demand by a contingent valuation survey of users (visitors) is theoretically equivalent to the travel cost approach. Where non-use, existence value benefits are likely to be significant, a contingent valuation survey that encompasses non-users provides the only method that will yield a theoretically-correct measure of total benefits.

The property value methodology is theoretically applicable to valuing acid deposition damages to outdoor art if there is a strong indication that proximity to the art is reflected in property values. However, practical application of this methodology is likely to encounter severe problems. It is not at all implausible that views of works of art, like views of scenic vistas, have a positive effect on property values. However, in many instances, disentangling the art from access to a park where the art is located may require considerable data. Any positive value associated with a view or proximity to a work of art may be overwhelmed by the negative effects of congestion resulting from numbers of visitors. Consequently, property value studies are difficult to utilize because of the necessity of holding constant many potentially confounding elements in the specification; given available resources, travel cost and contingent valuation surveys are likely to yield better estimates.

SUMMARY

Valuation of the benefits of avoiding acid rain damage effects requires different methodologies for different types of monuments and structures. Damage to marble and other soft stones in cemeteries can only be measured in a contingent valuation survey context. The decision of which methodology to apply depends on the type of material involved and whether or not it can be maintained. The next section reviews maintenance and cleaning procedures for basic cultural materials, including bronze, marble, limestone, granite, and brick. In the third section, we analyze the results of a mail survey, conducted by a non-profit group in Boston, which suggests some values of preserving cultural resources in the aftermath of Proposition 2 1/2 property tax reform.

For building facades, crude upper- and lower-bound estimates of the benefits of avoiding acid rain damages can be derived from case studies of reconstruction costs. In Section 4, information on reconstruction costs is combined with an inventory of structures listed in the Massachusetts State Register of Historic Places.

Finally, with respect to outdoor art, several approaches are feasible. Most appropriate for commemorative bronze statuary is the maintenance and replacement cost approach, which is applied to a Massachusetts inventory of bronze outdoor art in Section 5. The travel cost approach is used in Section 6 to value the unique national historic site at Chesterwood National Landmark, the workshop of Daniel Chester French, in West Stockbridge, Massachusetts. We have secured travel cost data from visitors to Chesterwood and have estimated user benefits based on the Clawson-Knetch travel cost model.

2

ACIDIC DEPOSITION EFFECTS ON CULTURAL MATERIALS

A large body of evidence from around the world has accumulated to document air pollutant damages to historical and artistic structures. Stone and metal are subject to particulate soiling and to erosion by acidic substances. The primary cultural materials of interest are building and monumental stones (such as marble, limestone, sandstone, and granite) and metals used in historical structures and statuary, especially copper and bronze.

BUILDING STONES

Erosion of building stones appears to result from surface weathering. It is widely believed that the mechanism of damage is the formation of salts through the reaction of constituent elements in the stone or mortar, particularly calcium compounds such as calcium carbonate, with air pollutant gases, SO_2 or NO_2, or aerosols, sulfates, and nitrates (Lucket, 1972; Winkler, 1975; Arnold et. al., 1976). Niesel (1979) reports that weathering of porous building stone containing lime is generally characterized by the accumulation of calcium dihydrate in the near-surface region. The'rate of such damage is affected by the permeability of the stone and moisture content; air pollutants are transported within the stone by moisture. The soluble minerals are dissolved and leached -- the more-soluble inward and the less-soluble toward the surface, often forming a surface crust. The formation of a hard, nonporous layer renders the surface susceptible to a type of efflorescence called "crystallization spalling," which is exacerbated by alternate freezing and thawing.

Calcareous stones that are directly exposed to rainfall undergo nearly continuous erosion, as the acid dissolves the calcium carbonate and the calcite granules break away (Gauri, 1979). Even weak acids like ordinary vinegar or lemon juice will react vigorously with those materials, eroding surfaces and leaving increasingly more surface area open to erosion and dirt collection. This activity is most visible when carved, decorative surface detail is dissolved away or covered with blackish, gypsum crusts that eventually spa11 off, taking surface detail with them.

Particles that carry acids and soluble salts also contribute to the chemical erosion of building stones (National Research Council, 1979). Evidence exists that carbonaceous particles from fossil fuel combustion promote the oxidation of sulfur oxide to sulfate (Del Monte et al., 1981). Also, certain sulfur and nitrogen compounds that form in the pores and on the surfaces of calcareous stones support the growth of bacteria (Thiobacillus Thioporus, Nitrobacter, and Nitrosomonas), which in turn attack not only calcareous stones but also the silica in brownstone and granite; porous brownstones are particularly susceptible. The harmful effects include both surface crust formation and binder decay. Hence, many conservators believe that regular cleaning of buildings and monuments preserves their surfaces in addition to improving their aesthetic appearance, and that these activities would be less critical in the absence of acid deposition.

The rate of erosion differs for marbles of different grain size, and finer-grained marbles erode more rapidly then coarse-grained stones (Baer and Berman, 1983). Baer and Berman also found that weathering rates for marble tombstones, measured in terms of loss of thickness, varied from near zero in arid, rural areas (Custer and Santa Fe National Cemeteries) to 3.6 mm/100 years in a high-rainfall, urban Philadelphia exposure. Softer limestone is believed to erode more quickly than marble, but our knowledge of brownstone erosion is insufficient to suggest rates of damage. Granite and brick are relatively less susceptible to erosion damage by acid deposition or other air pollutants, although the mortar used in binding the stones contains lime and is therefore susceptible to erosion from acid deposition.

COPPER AND BRONZE

Copper and copper alloys are used in a variety of practical and ornamental ways. Copper-clad roofs are common on many old historic buildings. Use of copper extends from simple flashing to highly complex domes and other roofing shapes. Copper-based bronze alloys are also the primary materials from which artists and sculptors have created outdoor art. Bronze is easily cast into intricate shapes and bears up well under normal weather conditions.

In the presence of sulfates and chlorides, however, copper and bronze surfaces corrode, forming a coating of surface salts. The formation of these corrosion products varies with sulfate and chloride concentrations, humidity, and temperature. Simpson and Harrobin (1970) reported that the rate of copper corrosion varied from 0.9 to 2.2 mm/year in industrial atmospheres to 0.1 to 0.6 mm/year in rural areas. The formation of the green patina of corrosion products on the surface of copper roofs and statues protects the underlying structure somewhat by reducing the rate of erosion due to contact with sulfates and chlorides. However, the presence of even dilute acids dissolves some of the surface salts and causes loss of material. The loss of surface material occurs quite rapidly in areas subject to low pH rainfall, and conservators have reported significant damage to new copper roofs in 15 years (Chase, 1983).

Efforts are underway in many areas to preserve outdoor bronzes by various methods. Fogg Art Museum (Cambridge, MA) conservators have reported successful treatment of outdoor bronze statues and reliefs by applying plastic-based coatings over a chemically-cleaned surface. Waxes must be applied regularly to prevent the natural forces of rain and wind from eroding the plastic coating. The plastic coating must be renewed every four to five years; application is thus limited (economically) to more accessible art works for which extensive scaffolding is not required. No long-lived preventive maintenance procedures are currently available for the copper sheeting used for gutters, roofs, downspouts, and other structures.

REFERENCES

Arnold, L., D.B. Honeyborre, and C.A. Price. 1976. "Conservation of Natural Stone." Chemical Industry (London) 8: 345-347.

Baer, N.S., and S.M. Berman. 1983. "Marble Tombstones in National Cemeteries as Indicators of Stone Damage: General Methods." Paper presented at the Annual Meeting of the Air Pollution Control Federation. June 19-24.

Chase, S.B. 1983. Personal Communication from The Society for the Preservation of New England Antiquities. September.

Del Monte, M., C. Sabbioni, and 0. Vittori. 1981. "Airborne Carbon Particles and Marble Deterioration." Atmospheric Environment 15: 645-652.

Gauri, K.L. 1979. "The Effect of Acid Rain on Structures." Contained in Acid Rain: Proceedings of the National Convention Workshop Session, American Society of Civil Engineers. Boston, MA. Pp. 57-75.

Lucket, S. 1972. "Investigations Concerning the Protection Against Air Pollutants of Objects of Natural Stone." Staub Reinhalt, Luft 32: May.

National Research Council, Subcommittee on Air Particles. 1979." "Airborne Particles." Baltimore, MD: University Park Press.

Niesel, K. 1979. "The Weathering of Building Materials in Atmospheres Containing Sulfur Oxides: A Literature Discussion." Fortsch, Mineral 57: 68-124.

Simpson, J.W., and P.J. Harrobin, eds. 1970. The Weathering and Performance of Building Materials New York, NY: Wiley-Interscience.

Winkler, E.M. 1975. Stone: Properties and Durability in Man's Environment. 2nd Edition. New York, NY: Springer-Verlag.

3

USE AND NON-USE BENEFITS OF PRESERVING CULTURAL AND HISTORICAL MONUMENTS, BUILDINGS AND OUTDOOR ART: THE CONTINGENT VALUATION APPROACH

Contingent valuation survey methods have been widely used to value the aesthetic benefits of environmental policy. A major advantage of the methodology lies in the simplicity of the direct question format, which can be administered either by trained survey personnel or distributed by mail and self-administered. A randomly-selected sample of the entire population that includes users and non-users will yield total benefits that encompass use and non-use aspects.

CRA was able to test the direct question willingness-to-pay method by adding two questions to a funding survey sponsored by a non-profit preservation group in Boston. The questions devised by CRA asked respondents whether they would be willing to contribute to a fund-raising effort to preserve buildings, outdoor art, and historic cemeteries in the context of reduced local revenues.* An additional question described the eroded condition of marble gravestones in the Northeast and asked what actions, if any, people would be likely to undertake to preserve the gravestones of their ancestors. The questions are included in Appendix 3A of this section.

The results reported herein are based on a small sample of 31 respondents who participated in a mail survey. The response rate was under 5 percent, as is normal for mail surveys. Normally, 5 percent response rates are unacceptable, but a recent study by researchers at Wyoming University (1983) found no significant difference in results between a low-response mail survey and a high-response, door-to-door survey of household willingness to pay to avoid the effects of ozone health alerts.

*Proposition 2 1/2 passed in 1982 and limited increases in property tax revenues to 2.5 percent of full and fair market value.

Table 3-1 shows that, out of an average total household contribution to charities and other "good causes" of $272, sponsorship of the "arts" accounted for about $21. However, only 11 of 29 respondents reported a willingness to make a contribution at all, and the median contribution amounted to zero. Table 3-2 shows that, on average, less than half of the total "arts" contribution, or $9, was assigned to preservation activities, and only 10 of 31 respondents were willing to contribute. This preservation total was further allocated as follows: 61.94 for historic graveyards, $3.46 for historic buildings, and $3.60 for outdoor art. In response to the question on preserving gravestones of ancestors, only 7 of 30 indicated a willingness to spend any money, while 20 indicated either "no interest" or "no ancestors buried in the Northeast." The average present value investment amounts to $33, or about $3.30 per year in annual contribution at a 10 percent discount rate for a 100-year lifetime.

The normal utility function for evaluating a willingness to pay to avoid a loss, an equivalent surplus measure, is derived from

$$u(p,y;s) = u(p,y;s) + \varepsilon_j \qquad (3\text{-}1)$$

where p=l if the good is preserved and 0 if it is not. Then, when offered the choice of accepting the existing or inevitable condition p=O or paying some amount, $A, to insure p=1, the individual will select $A so that

$$u(o,y;s) = v(1,y-\$A;s) \qquad (3\text{-}2)$$

and

$$v(o,y;s) + \varepsilon_0 = v(1,y-\$A;s) + \varepsilon_1 \qquad (3\text{-}3)$$

Although $A is a fixed number for an individual, it is a random variable for the econometric investigator, since the utility function u(p,y;s) is known only up to a random component. Statistical techniques are available to obtain a measure of $A by solving 3 for $A and choosing a form of the utility function. In the case of our limited survey data, the number of zero observations requires a Tobit estimator, but a preliminary regression analysis suggests that none of the socioeconomic variables are significantly different from zero. Hence, we present only the mean and median as a measure of individual willingness to pay benefits.

These results, though interesting, cannot be accepted with a satisfactory degree of confidence and are reported only to demonstrate the methodology. They are based on a small sample with a response rate of less than 10 percent. Nevertheless, the results may provide a guide in that they appear to be biased on the high side. The median income of the sample, $27,500, as shown in Table 3-3, is well above the Boston SMSA median of $18,265 (1980 Census); the median educational achievement of 16 years on average is also high; and the median age of 34 years is somewhat below that of the SMSA. All of these biases would seem to contribute to an upward-biased mean value in our small sample.

Table 3-1

ANNUAL WILLINGNESS TO PAY FOR VOLUNTARY GOODS

Contribution	Sample Size (#)	Mean ($)	Median ($)	Respondents With Non-Zero WTP (#)
United Way	29	38.72	0	13
Public TV	29	15.00	15.00	17
Poverty Relief Agencies	29	48.76	0	11
Medical Research	29	17.76	3.00	15
Wildlife Organizations	29	6.66	0	12
Colleges, Universities	29	79.82	20.00	15
Consumer Protection	29	9.31	0	14
Political Parties	29	29.38	0	13
Environmental Protection	29	2.86	0	6
Nuclear Disarmament	29	4.83	0	7
Sponsorship of the Arts	29	20.69	0	11
Total	29	272.07	160.00	26

SOURCE: Charles River Associates, based on a survey conducted by Architectural Preservation Associates, Boston SMSA, 1983.

Table 3-2

WILLINGNESS TO PAY FOR PRESERVATION GOODS ,

	Sample Size	Mean	Median	Respondents With Non-Zero WTP
Total Sponsorship of Arts (Annual)	29	20.69	0	11
For Preservation (Annual)	31	9.03	0	10
of which for				
Historic Graveyards	31	1.94	0	8
Buildings	31	3.46	0	9
Outdoor Art	31	3.60	0	9
Willingness to Upgrade Cemetery's Monuments (One-time Cost)	30	33.00	0	7

Replace Monument - $400	2
Substitute Marker - $150	
Protective Maintenance - $70	1
Bronze Plaque - $30	4
Photograph - $10	0
No Ancestors in NE - $0	10
Not Interested - $0	13
Total	30

SOURCE: Charles River Associates, based on a survey conducted by Architectural Preservation Associates, Boston SMSA, 1983.

Table 3-3

SOCIOECONOMIC CHARACTERISTICS

	Sample Size	Mean	Median
Males	15		
Females	16		
Age (Years)	29	34.8	34.0
Education (Years)	30	17.2	17.0
Household Income ($)	27	35,740	27,500
Full-time (# Workers)	29	1.29	1
Part-time (# Workers)	29	0.24	0
Ethnic Origin	29		
Caucasian	27		
Hispanic	1		
Black	1		
Other	0		

SOURCE: Charles River Associates, based on a survey conducted by Architectural Preservation Associates, Boston SMSA, 1983.

In small samples, mean values are very sensitive to outliers; consequently, we have reported the median value for all benefit estimates. In each category of preservation benefits -- historic graveyards, buildings, outdoor art, and private gravestones -- the median value is zero, so that it is likely that the real willingness to pay to preserve these structures is closer to zero. If we assume that the sample can be partitioned into two independent distributions of zero willingness to pay for preservation and non-zero willingness to pay, then the median of each distribution is 0 and 17.50, respectively. Recombining distributions yields a value of $5.65 for total household willingness to pay for preservation. This value breaks down to $1.29 for historic graveyards, $2.90 for buildings, and $1.45 for outdoor art. In addition, the annual willingness to pay to preserve ancestral gravestones amounts to $0.70.

Conceptually, these values may be interpreted as a maximum willingness to pay to preserve these cultural resources. To the extent that maintenance or reconstruction is possible at less cost, these values overstate true benefits. For gravestones, where preventive maintenance and replacement are costly and little expenditure is observed, these values approximate a benefit measure. For buildings and outdoor art, it is necessary to examine data on maintenance and reconstruction costs to determine the cost of avoiding acid deposition damages.

REFERENCE

University of Wyoming. 1983. Experimental Approaches for Valuing Environmental Commodities: The Ozone Experiment. Prepared for the Office of Policy Analysis, Environmental Protection Agency. July.

APPENDIX 3A

ARCHITECTURAL PRESERVATION ASSOCIATES
10 CHANNING PLACE CAMBRIDGE, MASSACHUSETTS 02136

Bonnie Marxer
Heli Meltsner

Telephone
(617) 492-6169

August 4, 1983

Dear New Englander:

Architectural Preservation Associates, a group of preservation consultants, is working with the Society for the Preservation of New England Antiquities, a non-profit organization, on a study of some key problems in preserving buildings and monuments of cultural, historic, and architectural importance in New England. In this study, we are concerned with the deterioration that comes from forces of weather and air pollutants. These pollutants are rapidly eroding the artistic carved detail on stone buildings and monuments, and are corroding the surfaces of copper and of bronze statues. Even paint is affected. The current emphasis on reducing local and state budgets has resulted in the curtailment of many government services, including the types of cleaning and protective work that preserve our architectural and cultural landmarks from pollutant damages.

For our study, we need to know the level of concern about this problem. Please take five minutes to fill out the enclosed questionnaire and return it in the enclosed self-addressed, stamped envelope.

Sincerely yours;

Sara Chase

Bonnie Marxer
Heli Meltsner

Sara Chase
Director of Consulting Services
Society for the Preservation
of New England Antiquities

Bonnie Marxer
Heli Meltsner
Architectural Preservation
Associates

SURVEY QUESTIONNAIRE

1. It is estimated that a great deal of money would be needed to protect some of the most important cultural, historical, and artistic sites and monuments in the Boston area. How much would you be willing to contribute to this effort? We recognize that there are other worthy organizations and causes to which many citizens already contribute. To get an accurate indication of how much money might be raised, please indicate how much you plan to give to these various organizations and causes in 1983. This is not a pledge and your name or address will not appear on this survey form-but please be as accurate as possible so that our financial planning can be gauged accordingly.

	1983 Contribution
United Way	$ ________
Public Television - Channel 2	$ ________
Agencies Dedicated to Relief of Hunger and Suffering, such as CARE, OXFAM, etc.	$ ________
Medical Research including American Cancer Society, Jimmy Fund, March of Dimes, Heart Fund, etc.	$ ________
Wildlife Organizations, such as Greenpeace, Audubon, Wildlife Federation, etc.	$ ________
Colleges, Universities, and Other Educational Institutions	$ ________
Consumer Protection Groups, such as Fair Share, Common Cause, Mass. PIRG	$ ________
Political Parties or Candidates for Federal, State, or Local Electoral Office	$ ________
Environmental Protection, such as Sierra Club, Friends of the Earth, Natural Resources Defense Fund, etc.	$ ________
Nuclear Disarmament Organizations	$ ________
Sponsorship of "The Arts", including Opera, Theaters, Symphonies, Museums, and Preservation Groups	$ ________
TOTAL	$ ________

2. Of the amount of money you plan to contribute to "the arts" in 1983, how much would you contribute to an organization that worked to preserve historic building facades and outdoor art, including historic graveyards? Of that total, how much would you ask that organization to use for each of the purposes stated below?

Total Contribution to an Organization to Combat Erosion Damages to Cultural and Historic Sites $ ________

for a. Restoring and Preserving Monuments -in Historic Graveyards ________%

b. Purchasing Easements (Ownership Rights) to Preserve the Appearance of Buildings of Historic and Artistic Significance ________%

c. Preserving and Protecting Existing Public Statues and Outdoor Art ________%

d. Other ______________________________ ________%

____

3. Could we count on this contribution each year?

____ Yes, an annual contribution

____ No, a contribution for 1983 only

4. We have also noted in our work in cemeteries that the inscriptions on many marble and sandstone gravestones erected prior to 1930 are rapidly becoming unreadable due to erosive action of weather and other elements. If you have ancestors buried in the Northeast, it will be necessary to take action soon to avoid the total erosion of names and dates on their gravestones. Which of the actions below would you be likely to take? Check one.

		Typical One-Time Cost	Duration
______	a. Replace the stone with a granite monument	$400	500 years
______	b. Substitute a granite marker for an upright headstone	$150	50-100 years
______	c. Endow a fund to apply a protective coating to the stone monument every 3 to 5 years for 50 years	$ 70	50 years
______	d. Install a small bronze plaque on the headstone with the name and date	8 30	100 years
______	e. Photograph (8"x10") the headstone and burial plot in their current conditions	$ 10	NA
______	f. No ancestors buried in the Northeast	$ 0	NA
______	g. Take no action -- not interested	$ 0	NA

SOCIOECONOMIC DATA

1. Age _______ (years)

2. Sex : ______ Male
______ Female

3. Citizenship: _____ U.S.
_____ Foreign ____________________ (please give country)

4. Education: ______ (years completed);

Please indicate highest diploma degree obtained:

____ High School/Trade School
____ College
____ Graduate School
____ Other __________________________
____ None of the Above

5. Household Size: _____ (adults)
_____ (children -- 18 and over)
_____ (Children -- 17 and under)

6. How many adults in your household work?
_____ full-time _____ part-time

7. Annual family income: Please check one

_______ $0-4,999 per year
_______ 5,000- 9,999
_______ 10,000-14,999
_______ 15,000-19,999
_______ 20,000-24,999
_______ 25,000-29,999
_______ $30,000-$34,999 per year
_______ 35,000-39,999
_______ 40,000-49,999
_______ 50,000-74,999
_______ 75,000-99,999
_______ $100,000 and over

8. Ethnic Background

_______ White -- not of Hispanic descent
_______ Black -- not of Hispanic descent
_______ Hispanic
_______ Native Indian or Native Alaskan
_______ Asian or Pacific Islander
_______ Other __________________________

4

AIR POLLUTANT DAMAGES TO HISTORICAL BUILDINGS: COSTS RECONSTRUCTION

Historic buildings contain a wide variety of materials that are subject to air pollutant damage, especially damage caused by acid deposition. This damage commonly manifests itself in erosion of the detail on stone surfaces, deterioration of mortar, and failure of copper roofs and gutters, ironwork, and other structural material. Most of this material can be replaced, though sometimes only at great cost. Some preventive maintenance is possible in the form of cleaning or painting, but for stone facades, mortar, and copper materials, no successful protective coatings are available. Thus, reconstruction and replacement costs are a major element in calculating damages.

Conservators have even developed techniques to restore carved detail to eroded surfaces through adhesive compounds, and our analysis is based on the proposition that it is possible to restore historic buildings to near-original condition by replacement and reconstruction of damaged areas. The benefits of reduced air pollutant damages are then reflected in greater material lifetimes and less frequent maintenance, replacement, and reconstruction.

AVOIDANCE COST APPROACH

The avoidance cost approach requires detailed data on the costs of cleaning, reconstructing, and replacing acid-susceptible materials on a per-unit basis. Applying this cost data systematically to a given population requires an inventory of buildings with detail on amount and type of susceptible material. Finally, this approach requires damage function information on the change in material lifetimes associated with some reduction in emissions loadings. The requisite damage functions are, as yet, unavailable, and the following analysis proceeds through the first two steps and then offers some trial benefit calculations based on assumed changes in material lifetimes.

SOURCES OF COST DATA

The objective of the case studies was to gather and report on actual market cost figures from the past five years for the maintenance, preservation, or replacement of those materials in historic building exteriors that are known to be susceptible to acid deposition damage. This task was under the direction of staff members of the Society for the Preservation of New England Antiquities, who are quite familiar with many of the buildings for which cost data were evaluated. The materials studied included copper, bronze, iron, brick, terra cotta, limestone, sandstone, marble, paint, and concrete. A total of 643 buildings were reviewed; all were located in Massachusetts and were 50 years old or older.

Four major sources provided most of the assembled cost information: 1) governmental preservation grant projects; 2) Investment Tax Credit Rehabilitation projects; 3) governmental and institutional rehabilitation and maintenance projects; and 4) discussions with materials conservation experts. To estimate the number of historic buildings susceptible to acid deposition damages, their approximate sizes, and types of materials contained, the Inventory of the State Register of Historic Places was tabulated.

1. GOVERNMENTAL PRESERVATION GRANT PROJECTS

A. MASSACHUSETTS HISTORICAL COMMISSION (MHC) GRANTS. This state-administered program makes grants available for design and architectural work related to the interior and exterior restoration of buildings listed on the National Register of Historic Places, which includes buildings federally designated as being of national historic or architectural significance.

We selected from the grant files final project reports that clearly listed work on exteriors involving susceptible materials. Report format was fixed but the degree to which the costs were broken down varied. For all projects we recorded the building's name, date of construction, total grant figure, and actual cost figures. On projects that were not accomplished, the estimated cost figures were recorded.

Work was not always undertaken to repair air pollutant damages, but such projects still proved useful if they pertained to the replacement or reconstruction of acid-susceptible materials. For instance, the Sundial Building of New Bedford had replacement costs for susceptible materials in its grant, but the actual cause of damage was an explosion that had blown off its top floors.

When lump-sum costs were reported, we itemized the work they encompassed; some costs attributable to non-susceptible materials were necessarily included.

For instance, roofing costs did not always break out metal work as a separate item, so that the cost of the roofing materials not susceptible to acid deposition damage and the cost of the metal flashing, gutters, and downspouts that are susceptible were not always distinguished.

Square footage of work accomplished was not normally included in the reports. A cost figure for masonry repointing in one building might refer to a small patching job while another figure might refer to repointing of an entire building. However, some information was gathered on the extent of the work through interviews with project managers and builders, and through general knowledge of specific projects.

Despite these caveats, figures gathered from the MHC grant files were a valuable resource for the cost replacement methodology. They were easily retrievable, accurately reported, and the degree of cost breakdown, though less than perfect, was better than that encountered in other sources used later.

B. LOWELL HISTORIC PRESERVATION COMMISSION GRANTS. The Lowell Historic Preservation Commission administers a grant program for exterior and facade rehabilitation for properties of key historical importance to the Lowell Historic Park or Preservation Districts.

The data collected from this study were similar to those of the MHC grant study and presented the same problems, though the final reporting procedure made data collection more difficult. The cost figures also included work for both renovation and rehabilitation for new uses, as well as for preservation or replacement of historic material.

2. INVESTMENT TAX CREDIT CERTIFICATION APPLICATIONS

A second major source of cost figures was the Historic Preservation Certification applications filed under the Tax Reform Act of 1976 and the Economic Recovery Tax Act of 1981. Consultants examined applications submitted between 1977 and 1982 to the State Historic Preservation Officer.

IRS regulations provide that owners of buildings listed in or eligible for entry in the National Register may receive tax credits if, in substantially rehabilitating their buildings, they adhere to standards established by the Secretary of the Interior. Work performed must be thoroughly described on the application in drawings and photographs.

From these files, data were collected on each building, including total project costs and information about the type of work proposed or completed. Applications do not include a detailed breakdown of cost figures, so it was necessary to contact owners, architects, contractors, and developers of the projects to estimate cost figures for specific aspects of each project.

The drawbacks to interviewing for cost figures are apparent. Contacting by telephone or in person the several people needed for each project is a time-consuming task. Unlike researching the grant files, approaching owners, contractors, and others required their cooperation. It was necessary to summarize the study's objectives, and we found some of the interviewees skeptical of the study's ability to isolate and assign a dollar value to acid-susceptible materials from the total cost of each item of work. Nevertheless, important information was obtained from some interviews. While individuals were sometimes unable to supply a breakdown of cost figures for ITC Certification applications, in many cases they were able to suggest other expert contractors whose information proved extremely useful.

The cost figures that were collected through the ITC interviews are not directly comparable to those collected from grant projects. ITC projects are allowed tax credits for improvement of historic structures and are most often larger rehabilitation projects, whose cost figures include items necessitated by the reuse of a building. For instance, an ITC rehabilitation masonry repair figure can include the cost of inserting masonry openings required for a new public use. In using these figures, one must factor out such additional costs not related to acid deposition damage to susceptible materials.

As might be expected, almost no one reported replacing, maintaining, or repairing materials because of acid deposition damage. Rather, costs were incurred due to general weathering, restoring a structure's original facade, or rehabilitating for new uses while improving a structure's stability and general appearance.

In conclusion, using ITC project costs can prove a valuable source of information if researchers are able to account for the extra rehabilitation costs. Without this ability, and with the greater time commitment required by the interviews, the usefulness of this source of information becomes limited at best.

3. GOVERNMENTAL AND INSTITUTIONAL REHABILITATION AND MAINTENANCE PROJECTS

Actual cost figures were also obtained from agencies concerned with the upkeep of governmental buildings and maintenance departments of local universities, both of which own historic buildings. In the latter group, we contacted the directors of the physical plants of four Boston universities. Only Harvard University provided data, but these were useful and covered many historic buildings. When other universities computerize their building project costs, as Harvard does, they will become more reliable sources of both maintenance and rehabilitation costs.

From the local governmental agencies, we identified a cross-section of large/ small, urban/suburban Massachusetts towns and counties. From these we eliminated a fair number that had undertaken little or no maintenance or rehabilitation work in the past five years. The remainder yielded a small amount of information. This phase of the project took place between June and August, when government fiscal year-end accounting tied up records and restricted access. A future study could avoid this timing problem. However, local records are geared to providing overall figures for accounting purposes and are not attuned to preservation issues; therefore, their cost figures were often inextricably combined with costs for work not applicable to the study.

Government agencies at the state level were more forthcoming, and their information was more centralized in several agencies. A survey of Massachusetts District Commission (MDC) properties was hampered by an inaccessible storage site and lack of an index of buildings by age or type of work done, whether interior or exterior. MDC records, however, are likely to contain considerable cost detail.

At the national level of historic importance, we traveled to the Lowell National Historic Park to evaluate and use records of spending on park projects involving historic buildings. Almost all spending was devoted to replacing, maintaining, or preserving historic building material rather than to general rehabilitation. Thus, this proved to be the best source for long-term maintenance costs encountered in the study. The work of the Lowell department is not extensive, however, which suggests that more valuable data should be collected from other National Park Service sites.

4. CONSULTATIONS WITH MATERIALS CONSERVATION EXPERTS

During the last phase of the study, interviews were conducted with several materials conservation experts at the National Park Service's Technical Services branch. They provided information on acid deposition research and were able to cite specific projects involving preservation or restoration of materials damaged by acid deposition.

During the last phase, we also interviewed several specialists in masonry repair and cleaning. From them, we were able to collect figures on many historic buildings. They were also able to provide unit costs for cleaning and repair. We concluded that, in general, these specialists were perhaps the most accurate source of replacement, repair, and maintenance cost figures for the susceptible materials. A cost replacement methodology should integrate their figures, since their ability to provide unit costs allows actual damage figures to be estimated for many buildings for which a detailed breakdown of costs is unavailable.

INVENTORY OF STATE REGISTER OF HISTORIC PLACES

In order to arrive at an estimate of the number of historic buildings in Massachusetts that contain materials affected by acid deposition, we used the State Register of Historic Places as a master list. We selected and evaluated a sample of 129 entries out of a total of about 1,300 (well over 6,000 individual buildings) to discover how many buildings in the State Register were constructed of susceptible materials. We found that of the 129 buildings evaluated, 117 contained acid-susceptible stone, mortar, or metal; the remainder were primarily wood structures. Of this total, 83 were brick facades, 21 were marble or limestone,* 7 were sandstone, and 2 were granite. Sixteen of the buildings contained some amount of copper materials.

For each entry sampled, we listed the acid-susceptible materials and estimated the number of structures, as well as their size and complexity of facade. Buildings were categorized as small, medium, and large. We also classified buildings by the complexity of reconstructing facades that referenced the type and amount of decorative trim or artistic material involved.

To extrapolate from the sample requires some adjustment to account for the fact that the Massachusetts Register contains not only individual nominations of historic buildings, but multiple resource and historic district nominations, which group buildings in large areas together and, in the interest of brevity, do not itemize the buildings' materials, condition, size, or level of decorative trim. There are over 5,000 individual buildings, predominantly brick, that are included in historic district nominations. We used this information to extrapolate from the sample to the population of buildings. The total number of structures in the Massachusetts Register of Historic Places is estimated at between 6,400 and 7,000.

---

*It should be noted that this sample is somewhat skewed, as Massachusetts has more brownstone buildings than marble or limestone buildings. However, many of the brownstone buildings may be listed in historic districts with many buildings, but only in a single entry in the Massachusetts Register.

COSTS OF CLEANING, RECONSTRUCTING, AND REPLACING MATERIAL SUSCEPTIBLE TO DAMAGE FROM ACID DEPOSITION

The cost information obtained from the 643 case studies of grant and rehabilitation projects was then applied to develop the costs for cleaning, repointing, and replacing or reconstructing each type of material. It was anticipated that we would apply crude estimates of costs based on figures for small, medium, and large buildings. Instead, we found that actual market data for almost all of the 117 historical structures in our sample were available from our large number of case studies. Thus, the actual costs of cleaning, repointing, and reconstruction were available in almost all cases. These cost data were grouped according to small, medium, and large buildings, then differentiated according to simplicity or complexity of the reconstruction project. Replacement of copper flashing, for example, was categorized as simple, while replacing a carved marble pillar was designated as complex.

Table 4-1 shows that the largest category of expenditure is for repointing stone and replacing mortar. Reconstruction costs are about equally split between replacing copper materials and reconstructing or replacing marble and limestone facades. For brick and granite structures, expenditures attributable to acid deposition are limited to cleaning and repointing, while for marble, limestone, and brownstone structures, reconstruction costs are a significant factor.

These costs, which are presented in Table 4-1 for the small sample of acid-susceptible historic buildings, are extrapolated to the entire inventory of over 6,000 Massachusetts historic structures in Table 4-2. Because of the large number of brick facade structures, repointing costs overwhelm the other categories. It would cost an estimated $190 million to repoint all buildings on the Massachusetts Register in a given year. Cleaning and reconstruction costs are small by comparison, $27 and $11 million, respectively.

BENEFITS OF REDUCED ACID DEPOSITION

The translation from damage costs to benefits of reduced acid deposition requires a damage function in which changes in emissions are related to material lifetimes. Such relationships have yet to be developed. Instead, we pose the question: What is the current lifetime of materials under existing conditions? Further, what changes in material lifetimes might occur if emissions were halved? These assumptions on changes in material lifetimes are presented below:

Table 4-1

COSTS OF MAINTAINING AND RECONSTRUCTING ACID-SUSCEPTIBLE MATERIALS USED IN HISTORICAL BUILDINGS
(Thousands of Dollars)

	Number of Structures			Total Costs		
Material	Total	Size	Complexity	Cleaning	Repointing	Reconstructing
Acid-Susceptible	117			599	3,018	1,100
Brick	85	--	--	346	2,659	0
	26	Large	--	114	852	0
	35	Medium	--	180	1,432	0
	24	Small	--	52	375	0
Marble and Limestone	21			195	281	525
	3	Large	Simple	45	62	127
	2	Large	Complex			175
	4	Medium	Simple	85	179	25
	3	Medium	Complex			100
	3	Small	Simple	65	40	7
	6	Small	Complex			91
Brownstone	7			~46	~60	75
	0	Large	--	0	0	0
	5	Medium	--	~40	~50	48
	2	Small	--	6	~10	27
Granite	2			12	18	0
	0	Large	--	0	0	0
	1	Medium	--	7	10	0
	1	Small	--	5	8	0
Of Which Containing Copper	16			--	--	500
	7	--	Simple	--	--	50
	9	--	Complex	--	--	450

NOTE: All costs are in thousands of nominal dollars expended some time between 1978 and 1983. Hence, in 1983 dollars, these figures represent underestimates of actual resources required.

SOURCE: Society for the Preservation of New England Antiquities, based on case studies of actual expenditures.

Table 4-2

COSTS OF MAINTAINING AND RECONSTRUCTING
HISTORICAL BUILDINGS IN MASSACHUSETTS
(Thousands of Dollars)

Type	Number in Sample (#)	Total Buildings in Massachusetts Register (#)	Cleaning ($)	Repointing Mortar ($)	Reconstruction Costs ($)
Brick	85	5,970	24,301	186,756	- -
Marble	21	210	1,950	2,810	5,250
Brownstone	7	70	~460	~600	750
Granite	2	20	120	180	- -
Of Which Containing Copper	16	160	- -	- -	5,000
Not Acid-susceptible	12	120	- -	- -	- -
Total Sample	129	- -	599	3,018	1,100
Total Register	- -	6,390	26,831	190,346	11,000

NOTE: All costs are in thousands of nominal dollars, expended some time between 1978 and 1983. Hence, in 1983 dollars, these figures represent underestimates of actual resources required.

SOURCE: Society for the Preservation of New England Antiquities, based on an inventory of the Massachusetts Register of Historic Places.

Assumptions

		Existing	Reduced Emissions	Cost Factor (@ 10% Discount Rate)
Cleaning:	Brick	10 years	25 years	0.5177
	Marble	10 years	25 years	0.5177
	Brownstone	10 years	25 years	0.5177
	Granite	15 years	30 years	0.2539
Repointing Mortar:		20 years	40 years	0.1520
Reconstruction:	Marble	50 years	100 years	0.0085
	Copper	15 years	100 years	0.3147

The cost factor is derived from present value calculations using a discount rate of 10 percent and assuming that the first expenditure occurs at the endpoint of the material lifetime and extends 100 years. A sample calculation for cleaning brick, marble, and brownstone is provided below:

$$\sum_{t=1}^{10} \frac{1}{(1+r)^{10t}} - \sum_{t=1}^{4} \frac{1}{(1+r)^{25t}} = 0.1577$$

The first term is the present value of expending one dollar on maintenance and cleaning every 10 years (10t). The second term is the present value of the same expenditure every 25 years (25t). The term r is a 10 percent discount rate. The difference is the present value savings of a one-dollar maintenance and cleaning cost.

Applying these present value savings to the total cleaning, repointing, and reconstruction costs for all historic buildings in Massachusetts yields benefits of reduced acid deposition, as shown in Table 4-3. The greatest benefits continue to accrue to savings in repointing, due to the assumed doubling in material lifetimes from 20 to 40 years. The second-largest benefit component results from reduced cleaning costs for brick and stone facades. The relatively large costs for reconstructing marble are heavily discounted due to the long 50-year lifetime before savings commence. On the other hand, extension of the 15-year lifetime of copper under current conditions leads to a rapid accumulation of savings in replacement costs and relatively large benefits.

Under the damage rate assumptions stated above, the total present value benefit of costs avoided amounts to $44.4 million, as shown in Table 4-3. Since the cost figures from the case studies are not adjusted to 1983 dollars, actual benefits are higher, probably closer to $50 million. This

Table 4-3

BENEFITS OF REDUCING ACID RAIN DAMAGES TO PROPERTIES IN THE MASSACHUSETTS REGISTER OF HISTORIC PLACES
(Thousands of Dollars)

Type	Cleaning ($)	Repointing ($)	Reconstruction ($)	Total ($)	Total Buildings on Massachusetts Register (#)
Acid-Susceptible					
Brick	12,581	28,387	--	40,968	5,970
Marble	1,010	427	45	1,482	210
Brownstone	238	91	6	335	70
Granite	30	27	--	57	20
Of Which Containing Copper	--	--	1,573	1,573	160
Not Acid-Susceptible	--	--	--	--	120
Total	13,859	28,932	1,624	44,415	6,390

1) Assumptions on Changes in Material Lifetimes:

			Present Value Savings Factor
a) Cleaning:	Brick, Marble, Brownstone	10 years to 25 years	0.5177
	Granite:	15 years to 30 years	0.2539
b) Repointing	Mortar:	20 years to 40 years	0.1520
c) Reconstruction:	Marble	50 years to 100 years	0.0085
	Brownstone	50 years to 100 years	0.0085
	Copper	15 years to 100 years	0.3147

2) The discount rate is 10 percent in all calculations.

NOTE: All costs are in thousands of nominal dollars expended some time between 1978 and 1983. Hence, in 1983 dollars, these figures represent underestimates of actual resources required.

SOURCE: Charles River Associates, based on figures supplied by the Society for the Preservation of New England Antiquities.

figure represents a marginal benefit of future reduction in acid deposition. At a 10 percent discount rate (to infinity), annual costs amount to $5.0 million, which requires a willingness to pay of about $2.50 per family in Massachusetts. Results of the benefit survey reported in Section 3 suggest that Massachusetts residents are, in fact, willing to pay approximately that amount to preserve the facades of historically and culturally significant buildings.

5

BENEFITS OF PRESERVING OUTDOOR ART

Historically, sculptors have used either cast metals, mainly copper or bronze, or calcareous stones, especially marble, as artistic media. Techniques, including the use of clear-plastic coatings and waxes, currently exist to restore and preserve art work made of copper, bronze, and other metals damaged as the result of acidic deposition.* For marble and other soft calcareous stones, however, no acceptable protective maintenance procedures are available. The benefits of reducing sulfate-loading and acid deposition effects are the resulting savings in lower preventive maintenance expenditures or the value of irreparable damages avoided. Where preservation and maintenance techniques are being applied to outdoor art, the benefits manifest, themselves in maintenance cost savings. Where preservation and maintenance options are not available, the benefits of avoiding damages from acid rain are equal to the total consumer surplus loss that results from irreparable damage to structures.

INVENTORY OF OUTDOOR ART IN MASSACHUSETTS

The Massachusetts Department of Environmental Quality Engineering (DEQE) has conducted an inventory of all copper and bronze outdoor artworks. Responses from 133 out of 312 cities and towns have uncovered about 240 artworks, consisting mostly of free-standing statues and reliefs. A crude extrapolation

---

*A common procedure is to coat the metal with a plastic preservative film and then apply several coats of wax for protection from the elements.

by SMSA and non-SMSA suggests that there are about 340 such objects in the Commonwealth of Massachusetts.

These artworks include a number by prominent American sculptors, including 13 by Daniel Chester French, 5 by Augustus St. Gaudens, and 4 by Thomas Ball. Most of these works are historical or commemorative in nature, such as the Shaw Memorial (August St. Gaudens) in Boston, the Minuteman (Daniel Chester French) in Concord, the Mayflower Compact (C. Dallin) in Provincetown, and the Fisherman's Memorial (Leonard Craske) in Gloucester. Table 5-l provides a summary of these outdoor artworks by type. It is estimated that there are 258 statues, 32 reliefs, 14 fountains, 13 bells, and 6 busts.

Most of the outdoor artworks in Massachusetts are over 30 years old. Only about 15 percent of these sculptures have been commissioned since 1950, as shown in Table 5-2. The greatest number of works were commissioned in the period from 1901 to 1925. The dates of origin for a substantial percentage of the works are unknown, but we surmise that this is indicative of their age. Consequently, over 70 percent of these outdoor artworks have been exposed to the erosive effects of weather and air pollutants for 50 years or more.

COSTS OF RESTORATION AND PRESERVATION

The process of updating copper and bronze statues and other outdoor art includes both restoration and annual maintenance. Most outdoor copper and bronze that has been left unmaintained more than a few years develops a greenish oxidation coating that must be removed. Chemicals are used for this cleaning. Once the metal is cleaned, polished, and repaired, a protective plastic coating is applied to protect the metal from acidic elements. Even weak acids cause damage to metal, so that a protective coating would be necessary even if acid rain were reduced somewhat. The plastic coating must itself be protected from damage by abrasion and ultraviolet light. Waxes are well-suited for this purpose. However, the wax coatings are worn away by the elements and need to be renewed every six months or the plastic coating will break down rapidly. The plastic coating itself requires renewal every five years on average.

The costs of restoring and maintaining copper and bronze outdoor art vary with the size and complexity of the piece. Restoration costs vary from about $2,500 to $15,000 for large works like the Shaw Memorial outside the Massachusetts Statehouse. The range of costs for small, medium, and large pieces is shown in Table 5-3.

Table 5-1

INVENTORY OF COPPER AND BRONZE
OUTDOOR ART IN MASSACHUSETTS, BY TYPE

Type	Sample	Percent	Extrapolated
Statues	164	68.9	258
Reiefs	21	8.8	32
Fountains	10	4.2	14
Bells	6	2.5	13
Busts	5	2.1	6
Other	8	3.4	17
Unknown	24	10.1	- -
Total	238	100.0	340

SOURCE: Massachusetts Department of Environmental Quality Engineering.

Table 5-2.

INVENTORY OF BRASS AND BRONZE
OUTDOOR ART IN MASSACHUSETTS, BY AGE

Date Erected	Sample	Percent
pre-1850	1	0.4
1850-1875	16	7.1
1876-1900	29	12.9
1901-1925	56	25.0
1926-1950	28	12.5
1951-1975	24	10.7
1976-	10	4.5
Unknown	60	26.8
Total	224	100.0

SOURCE: Massachusetts Department of Environmental Quality Engineering.

Table 5-3

COSTS OF RESTORING AND MAINTAINING
COPPER AND BRONZE OUTDOOR ART
(Dollars)

Costs	Size of Art Object: Small	Medium	Large
Restoration	2,500-5,000	5,000-8,000	8,500-15,000
Scaffolding	--	2,000-8,000	8,000-15,000
Waxing and Repair per Year	400	650	1,000
Stripping and Recoating Every Five Years	500-1,000	I,000-1,700	1,700-3,000
Present Value at 10 Percent	8,320	19,137	35,442
Annual Cost	832	1,914	3,544

SOURCE: Charles River Associates, based on estimates by Sara Chase, Society for the Preservation of New England Antiquities,-and Arthur Beale, Fogg Art Museum, Harvard University.

Fixed costs for scaffolding, materials, and access to the monument depend greatly on size, varying from 0 for small pieces to $15,000 for the largest statues and reliefs, such as Boston's Shaw Memorial. Costs for renewing plastic coatings usually amount to about 20 percent of the restoration costs. Costs of biennial waxing and repair are primarily for labor and vary from about $400 to $1,000 per year. The present values of these restoration and annual maintenance costs at a 10 percent social opportunity cost amount to about $8,320 for small pieces, $19,137 for medium-size pieces, and $35,442 for large statues and three-dimensional reliefs.

COSTS OF AVOIDING DAMAGES TO OUTDOOR ART

The present value cost of preventing air pollution damage to copper and bronze statues in Massachusetts can be determined by applying the costs of preventive maintenance to the inventory of outdoor art, by size, as summarized in Table 5-4. Most busts and bells can be expected to fit into the class of small pieces. Most of the statues fit into the medium category, with almost equal percentages of small and large works. There are only a few large reliefs and fountains. Altogether, we estimate there are 95 small pieces, 169 medium pieces, and 51 large pieces of outdoor art in Massachusetts. The present value costs (10 percent opportunity cost of capital) of restoration and maintenance are estimated to be $5.8 million, or about $0.6 million per year.

These costs include those for restoring surfaces damaged by past acid deposition to their original condition. The present value of future preservation costs is less -- about $4,570 for small pieces, $12,637 for medium-size pieces, and $23,000 for large pieces. The total present value cost of preserving Massachusetts outdoor art from future acid deposition damages is estimated to be about $3.74 million, or $0.4 million per year.

These costs are relatively insensitive to the pH level of rainfall. Since even weak acids damage metal, these procedures and coatings would be required even if acid deposition were significantly reduced. Only if acid deposition were all but eliminated could these costs be avoided. Thus, the present value total quoted above represents the benefit of eliminating all acid deposition damages. The benefit of reduced maintenance costs for outdoor art that results from marginally reducing, but not eliminating, acid deposition is very small.

These costs of preventing damage can be construed as benefits only if we assume that the value of these statues and other art works to the public is greater than the costs of restoration and maintenance. Otherwise, it would be economically efficient to incur the loss in general welfare from the erosion of the artistic value of the work and use the restoration and maintenance funds on higher-valued activities. Since most of these outdoor

Table 5-4

MASSACHUSETTS COPPER AND
BRONZE OUTDOOR ART, BY SIZE

Outdoor Art	Total	Small	Medium	Large
Statues	238	48	153	37
Reliefs	30	16	8	6
Fountains	13	8	3	2
Bells.	12	12	0	0
Busts	6	5	1	0
Other	16	6	4	6
Total	340	95	169	51

SOURCE: Charles River Associates, based on information supplied by Massachusetts Department of Environmental Quality Engineering.

art objects are publicly-owned, allocating funds for restoration and preservation purposes requires the approval of local or state legislative or administrative bodies. That these statues and other art have been allowed to deteriorate in the past is due both to ignorance concerning the damages and. lack of effective cleaning and preservation techniques. Now there is evidence that public bodies are willing to spend the necessary funds for restoration and preservation.

The survey by Massachusetts DEQE revealed that 40 percent of the artworks for which information is available (40 art objects) have been cleaned and maintained in some fashion. Moreover, conservators at the Fogg Art Museum report a sharp increase in the number of contracts for restoration in recent years. The evidence suggests that efforts will be undertaken to preserve outdoor art in Massachusetts. Consequently, restoration and maintenance . costs are a measure of the benefits of eliminating the damages caused by acid deposition.

6

BENEFITS TO USERS OF PRESERVING IRREPLACEABLE OUTDOOR ART: AN APPLICATION OF THE TRAVEL COST METHODOLOGY

With respect to their care, the irreplaceable nature of certain statues, monuments, and other objects presents only two options: preservation or total loss. For copper and bronze statuary, preventive maintenance is an option through the use of procedures described previously. However, for statues carved from calcareous stone -- mainly marble, limestone, and sandstone -- no acceptable preventive maintenance procedures are available.* Without preventive maintenance options, the benefits of avoiding damages from acid deposition are equal to the total consumer surplus loss that results from irreparable damage to a structure.

Total consumer surplus has two components: a use value and a non-use value. The use value can be further broken down into a value to visitors plus the value of preserving the option to visit a site at some future time. For typical utility functions, Freeman (1983) concludes that option value does not exceed 5 percent of visitor use value. Thus, the estimation problem includes two components: a use value attributable to visitors and a non-use benefit of existence attributable to anyone. The former can be measured by using the Clawson-Knetch method to analyze data on the expenditures that visitors incur in traveling to and from a site. The latter existence value benefit is by definition divorced from use, so it can be quantified only by survey-based methodologies.

CRA has secured a small sample of data on the origins and destinations of visitors to the workshop of one of America's most famous sculptors, Daniel

---

*Various coatings have been tried, but all have been found wanting in some respect.

Chester French. Chesterwood is the Berkshire, Massachusetts, workshop of French, where the famous sculptor worked for 30 years. In it are contained many bronze, plaster, and marble carvings, including models of the statue of Lincoln in the Lincoln Memorial. Its grounds contain several bronze statues exposed to outdoor air pollutants.* From visitor data, it is possible to estimate a demand curve from which to calculate total consumer surplus benefits using the travel cost method.

CHARACTERISTICS OF VISITORS TO CHESTERWOOD

Chesterwood is open six months of the year and receives about 30,000 visitors in that time. The site lies nearly equidistant from Boston and New York City. It is primarily a regional attraction and draws most of its visitors from the New England and Mid-Atlantic regions. Table 6-1 shows that 48 percent of the visitors surveyed at Chesterwood in the summer of 1983 came from New England, while New York, New Jersey, and Pennsylvania accounted for 45 percent.

As is the case with many artistic and cultural exhibits, Chesterwood tends to attract visitors from the higher economic strata. A small sample of 44 respondents indicated that the average visitor is 42.6 years old and has completed 17.3 years of education. Over 50 percent had graduate degrees. Average family income amounted to almost $47,000.

Visitors arrived mostly by car on weekends, with an average party of 2.5 adults and 0.4 children per vehicle. Seventy-five percent of the visitors had come for the first time. The average length of a visit to Chesterwood is 2.2 hours. These basic visitor statistics are summarized in Table 6-2.

TRAVEL COST METHODOLOGY

The travel cost methodology estimates visitor-days or visitor-days per population for a given zone as a function of marginal travel cost, time inputs, and socioeconomic characteristics. Since most visitors to Chesterwood make at most one visit per year, the dependent variable must be defined as visitor-days per population for concentric zones that represent different trip (travel and time) costs. Mathematically,

$$V_{iz}/P_z = f\ (CT_{iz},\ V_{Tiz},\ V_{Ti},\ X_{Viz}/P_z)$$

---

*The bronze statues are subject to regular protective maintenance, but some air pollutant damage has occurred. The travel cost method can be used at Chesterwood and other sites to determine whether site benefits are worth any additional maintenance costs to preserve the outdoor art from damage.

Table 6-1

ORIGINS OF VISITORS TO CHESTERWOOD

	Visitors	Percent
State of Residence		
Massachusetts	18	40.9
New York	14	31.8
New Jersey	3	6.8
Pennsylvania	3	6.8
Maine	2	
Connecticut	1	4.5
Ohio	1	2.3
California	1	
Oregon	1	2.3
Total	44	100.0
One-Way Marginal Distance Traveled to Chesterwood on Day of Visit		
0 to 12 miles	20	50.0
13 to 25 miles	11	27.5
26 to 59 miles	6	15.0
60 to 100 miles	3	7.5
>100 miles		
Total	40	100.0

SOURCE: Chesterwood National Landmark, Survey of Visitors, Summer 1983.

Table 6-2

PROFILE OF VISITORS TO CHESTERWOOD

Characteristics	Number of Observations	Mean
Age	40	42.5 years
Education	39	17.3 years
Size of Party		
Adults	43	2.5
Children	43	0.4
Previous Visits		
None	30	
One	7	
Two or More	3	
Household Income	39	46,872
Adults Employed		
Full-time	41	1.4
Part-time	41	0.3

SOURCE: Chesterwood National Landmark, Survey of Visitors, Summer 1983.

where:

V_{iz}/P_z = the fraction of visitor-days to site i from zone z per population, P, of zone z;

CT_{iz} = cost of round trip travel from zone z to site i;

VT_{iz} = value of time in travel to and from zone z to site i;

VT_i = value of time spent visiting site i; and

X_{V_{iz}/P_z} = a vector of socioeconomic characteristics of visitors from zone z relative to the general population of zone z.

The proportion of visitor-days at a given site by residents of a given zone, z, relative to the population of zone z, is expected to decrease with distance as costs of travel and time increase. It is expected to increase with certain socioeconomic characteristics, such as income and education. The demand curve for visits from each zone can be traced out by multiplying the number of visits expected from more distant zones by the incremental price (increase in costs of travel and time beyond base zone) until a price is reached where no visits occur. Repeating the procedure and summing over all zones yields total consumer surplus.

MULTIPLE-DESTINATION TRIPS

Valuation of recreation sites using travel cost data has often been confounded by the fact that many trips have multiple destinations. This problem is particularly acute for Chesterwood, which is located in the Berkshire Mountains of western Massachusetts. The Berkshires feature many summer and winter attractions for outdoor enthusiasts and also offer a wide variety of summer cultural opportunities. Several noted performing groups make the Berkshires their summer home. Among these are the Boston Symphony Orchestra at Tanglewood, The Harlem Dance Studio at Jacob's Pillow, and various theater groups in Williamstown and Great Barrington. In addition to French's workshop at Chesterwood, there is the Sterling and Francine Clark Art Museum in Williamstown, which boasts an internationally-recognized collection of the works of Monet. Hence, visitors to the Berkshires have a wide range of cultural and recreational opportunities, and most trips undoubtedly have multiple destinations.

The multiple-destination problem is identical to that of separating and apportioning fixed and marginal costs. There is a fixed cost of travel to the Berkshires. Once there, a visitor is subject to a marginal cost to visit any particular site or attraction. The marginal cost represents the minimum willingness to pay to visit the site, while the total cost (fixed plus marginal) represents the maximum. The true value usually lies somewhere in between, but in the absence of specific information on the primary reason for the trips, there is no theoretically-defensible method for allocating fixed costs.

In order to have some basis for apportioning the fixed costs of a trip, a question was added to the Chesterwood survey that asked whether visitors would have come to the Berkshires if Chesterwood were closed for repairs. For visitors who answered 'yes', the marginal cost of travel to Chesterwood from a place of lodging in the Berkshires is the appropriate value to use. For visitors who would not have made the trip if Chesterwood were closed, the total cost of travel and time to and from the Berkshires should be attributed to visiting Chesterwood. The data obtained from 40 respondents showed that an overwhelming majority, 87.5 percent, would have made the trip even if Chesterwood were closed. For those visitors who would have come anyway, we apportioned only the marginal costs of travel to and from either their place of lodging or Tanglewood (summer home of the Boston Symphony Orchestra in Lenox) as the presumed principal destination. The distribution of one-way trip lengths is summarized in Table 6-1.

VALUE OF TIME

A key element in the treatment of overall factor costs incurred in visiting a site is the treatment of time. Time is an important element in any recreational endeavor, and its relative scarcity imparts value. Time in a recreational context has two components: a scarcity value reflected in the opportunity value of next-best use, and a commodity value of time in an existing use (Wilman, 1980). Its scarcity value in its best alternative use is referred to as "the value of time saved."

In transportation studies, the value of time saved is the difference between the positive value of the next-best use and the zero or negative value of time spent commuting. This value is reflected in the amount a commuter is willing to pay to save a given amount of commuting time by choosing a more expensive travel mode, such as a car, over some form of public transportation. Quantitative studies of mode choice in commuting to work yield values between 20 and 40 percent of the wage rate (Stopher, 1976). There are few studies of the value of time saved in a non-commuting situation. In one such study, Rae et al. (1982) found that visitors to Mesa Verde National Park were willing to pay, on average, $1.65 to $2.65 in increased entry fees to avoid waiting one hour at one cliff dwelling where access was limited to ranger-guided tours. This average range of values represents 10 to 16 percent of the visitors' average hourly wage rate, as computed from data on average annual income.* For some people, this value

---

*Annual income for Mesa Verde was $34,139 (1981 dollars) and this most likely includes some investment income. As a percent of wages or salary, this range of values should be adjusted upwards to compare with studies reported by Stopher (1976).

may include a significant negative value of time spent waiting outdoors in the hot Mesa Verde climate, while for others, time spent viewing the mesa and canyon scenery may represent a positive value. Comparatively, the drive through the Berkshire Hills of Massachusetts in the May to October period is likely to be a positive value. Thus, the Mesa Verde value is probably a reasonable guide to the value of time saved. For those driving fewer than 25 miles (one way) to Chesterwood, we assume the drive is through the scenic Berkshires and value it at the (lower) commodity value of time, which is assumed to be 10 percent of the hourly wage rate. For the small fraction of visitors driving from more distant points on busier highways and toll roads, the travel time is valued at its "value of time saved." We use 20 percent of the hourly family income for the latter.

Visitors to Chesterwood typically spend 2.2 hours on site, and time spent on site should be valued at its best alternative use. However, there are no published empirical studies of the value of time in leisure or vacation situations. In most cases, it might be expected that this value is less than the "value of time saved," since the latter compares the best alternative to the value of travel time, which is expected to be negative. In the Berkshires, as we noted above, travel is usually enjoyable, and it seems appropriate to value travel time and on-site time at the same rate, 10 percent of the average hourly wage rate.

VALUE OF TRAVEL EXPENSE, TRAVEL TIME, AND TIME ON SITE

The data on travel distance and travel time provide a means of estimating the total benefits of Chesterwood to visitors. For visitors who indicated they would have made the trip to the Berkshires even if Chesterwood were closed for repairs, the marginal distance and time from their overnight accommodations to Chesterwood were used as a basis of computation. For those few, 12.5 percent, who indicated that a visit to Chesterwood was the primary purpose of their trip, the full-trip distance to Chesterwood from point of origin plus any overnight lodging costs was used as the basis for estimating cost of travel and value of travel time.*

Travel costs were calculated simply on the basis of expenditures for gasoline only for visitors traveling no farther than 25 miles one way. The round trip mileage was divided by miles per gallon, and a price of $1.25 per gallon was applied. For visitors traveling more than 25 miles, an operating cost of 10 cents per mile plus lodging was applied.

Travel time was calculated by assuming an average speed of 30 mph for one-way trips of 25 miles or less, and an average speed of 50 mph for one-way trips longer than 25 miles. The value of travel time was determined by converting household annual income into an hourly wage rate. Annual household income was reduced to an individual hourly rate by assuming 2,000 hours for each

---

*None of these single-purpose visitors incurred overnight lodging costs.

adult in the household. This approach treats the household as a unified entity and attributes the same value of time to both a working and a non-working spouse. For a single individual with an annual income of $40,000 who travels for one hour, the fully-weighted value of time spent traveling would be

$40,000/(2,000 hrs) * 1 adult * 1 hr = $20.00 per hour

For a husband and wife with a combined income of $40,000, the value for both of time spent traveling would be the same:

$40,000/(2*2,000 hrs) * 2 adults * 1 hr = $20.00 per hour

However, if only the husband came to Chesterwood, his value of time would be half that of the single individual:

$40,000/(2*2,000 hrs) * 1 adult * 1 hr = $10.00 per hour

Finally, time on site, which averaged 2.2 hours per person, was valued in a similar manner to travel time. Annual household income was divided by annual working hours for all household members and multiplied by the number of adults from the household in the party.

Table 6-3 summarizes the average travel costs, value of travel time, and value of site time for the four distance zones. The average value for 0 to 12 miles, which represents 51.3 percent of the sample of vehicles, is 98.12. For 13 to 25 miles, which represents 25.6 percent of the sample, the average value is $9.11. The average values of visits from Zone 3, 26 to 59 miles, which is 15.4 percent of the sample, and Zone 4, 60 to 100 miles, which is 7.7 percent, are $17.67 and $25.81, respectively. These figures represent the average willingness-to-pay values in travel cost and time to visit Chesterwood National Landmark from four different distance zones.

CONSUMER SURPLUS BENEFITS

The economic benefit of the Chesterwood site for visitors is based on the concept of consumer surplus. Of the visitors who expended a small amount of time and money resources, some would have expended more. This additional willingness to pay is the consumer surplus, and it can be estimated by comparing rates of visitation for different zones. However, because a large fraction of the visitors to Chesterwood are visitors to the Berkshires rather than residents, this comparison becomes quite complex. In fact, there are about 1,660,000 annual visitor-overnights in the Berkshires each year. This translates into about 830,000 household trips split equally between north and south Berkshire County. Making certain assumptions about the proportion of visitor trips in winter and summer yields the breakdown shown in Table 6-4.

Berkshire County itself is only sparsely populated, with fewer than 150,000 people in total and fewer than 50,000 households. The 12-mile radius around

Table 6-3

AVERAGE TRAVEL COSTS AND TIME VALUES, BY ZONE, FOR VISITORS TO CHESTERWOOD

Zone (Miles)	Number of Visitors (#)	Travel cost ($)	Travel Time ($)	Site Time ($)	Total ($)
0 to 12	20	0.93	0.80	6.39	8.12
13 to 25	11	2.08	2.92	4.11	9.11
26 to 59	6	5.95	7.07	4.65	17.67
60 to 100	3	16.00	7.15	2.67	25.81
> 100	0	--	--	--	--

SOURCE: Charles River Associates, calculated from data collected at Chesterwood National Landmark, Summer 1983.

Table 6-4

RATE OF VISITATION BY ZONE

		Chesterwood		Population			
Zone (Miles)	Travel and Time Cost ($)	Percent of Visitors	Number of Households	Visitor Household Trips to Berkshire County	Resident Households	Total	Chesterwood Visitor Households as a Percent of Population Households
0 to 12	8.12	50.0	5,345	221,000	11,200	232,200	2.3602
13 to 25	9.11	27.5	2,939	131,200	22,760	153,950	1.9091
26 to 59	17.67	15.0	1,603	103,500	261,500	365,000	0.4392
60 to 100	25.81	7.0	748	0	603,320	603,320	0.1240
> 100	--	0	0	0	--	--	0
Total		100.0	10,689			1,354,470	0.7892

SOURCE: Charles River Associates, based on survey data from Chesterwood National Landmark; data on visitor-days from the Berkshire County Regional Planning Commission; and 1980 population data from the Bureau of the Census.

Chesterwood includes very few residents. Pittsfield, the largest city in Berkshire County with about 50,000 in population, lies in Zone 2. Zone 3 includes Albany, New York, and Springfield, Massachusetts, while Zone 4 includes Worcester, Hartford, and the more densely-populated areas in southwestern Connecticut as well as Dutchess and Schenectady counties in New York State.

The rate of visitation declines from 2.36 percent in Zone 1 to 1.91 in Zone 2 as travel and time costs increase. Beyond 100 miles, the rate of visitation in our sample drops to zero. Table 6-5 converts this information into a demand schedule. Multiplying expected number of visitor households by the demand price for the three separate demand curves with prices in zones 1, 2, and 3 set equal to zero yields a consumer surplus of 631,187.

This calculation assumes that visitors to Chesterwood come from zonal populations that exhibit similar socioeconomic characteristics, especially income (as a basis for value of time). This assumption is weak, and in fact the population of zones 1 and 2, with their large components of well-to-do tourists, probably differs significantly from that in zones 3 and 4. In such a case, the rate of visitation in zones 3 and 4 should be disaggregated to control for socioeconomic differences. The dataset, however, is not rich enough to justify the effort of further disaggregating zonal populations by income or other socioeconomic characteristics. Suffice it to say that if zonal incomes in zones 3 and 4 are less than incomes in zones 1 and 2, the ratio of visitation is biased downwards and the consumer surplus measure is understated by some amount.

Normally, this problem is easily overcome by regressing rates of visitation versus time and travel costs and other socioeconomic variables such as income. However, with only four travel zones, there are insufficient degrees of freedom to utilize a regression approach to the Chesterwood data. Moreover, with only 44 total respondents, further disaggregation of travel zones would yield highly-unreliable estimates for fewer observations per zone. Instead, some of the bias can be removed by using only travel cost and travel time in the calculation, since the total willingness to pay is very sensitive to time spent on site, especially by high-income tourists to Berkshire County. Such a recalculation yields a consumer surplus benefit of $44,581, although this figure is also an underestimate in that it includes the travel time of lower-income visitors from Zone 4. Omitting time altogether, however, yields a consumer value of only $23,752 and is conceptually incorrect.

Table 6-5

CONSUMER SURPLUS

Zone (Miles)	Willingness To Pay ($)	Percent of Visitor Households by Zone (%)	Number of Visitor Households by Zone (#)	Demand Price Zone 1=0 ($)	Number of Visitor Households (#)	Demand Price Zone 2=0 ($)	Number of Visitor Households (#)	Demand Price Zone 3=0 ($)	Number of Visitor Households (#)	Consumer Surplus ($)
0 to 12	8.12	2.3602	5,345	0	5,345					
13 to 25	9.11	1.9091	2,939	0.99	4,323	0	2,939			4,280
26 to 59	17.67	0.4392	1,603	9.55	994	8.56	676	0	1,603	15,279
60 to 100	25.81	0.1240	748	17.69	281	16.70	191	8.14	426	11,628
> 100		0	0	-						0
Total										31,187

NOTE: Willingness to pay includes travel costs, value of travel time, and value of site time.

SOURCE: Charles River Associates, based on data obtained from Chesterwood National Landmark, Summer 1983.

DAMAGES DUE TO ACID RAIN

The problem with using the Clawson-Knetch travel cost method is that it yields a value to the entire site. In the cases of Chesterwood and St. Gaudens in Cornish, New Hampshire, only small portions of their art collections are displayed outdoors, where statues are affected by acid rain damage. Determining what fraction of the total value of the Chesterwood collection is represented by exposed pieces would require the expert opinions of art appraisers. Suffice it to say that the consumer surplus benefit figures presented here represent a value to the total site and its collection, and that any damages due to acid rain must be significantly less.

The Clawson-Knetch travel cost methodology is most appropriately applied to sites where acid rain threatens to erode the value of the entire site; Preferably, the value of such a site would be embodied almost wholly in the exposed outdoor art pieces. Such sites, however, are rare. A fairly-common class of sites includes both artistic or commemorative statuary in a historical context. Battlefields, such as Concord Bridge or Gettysburg, are common examples. The travel cost methodology can provide a value to the entire site, but it is incapable of separating out the potential loss in value caused by acid rain damage to statuary or gravestones from the value of the site as a place of historical significance. Such a value could be quantified only in a contingent valuation survey that asked people how they would behave if the outdoor art were threatened or lost.

REFERENCES

Freeman, Myrick. 1984. "The Sign and Size of Option Value." Journal of Environmental Economics and Management (forthcoming).

Rae, B.A., J. Hausman, and S. Vitka 1982. Benefits and Costs of Improving Visibility: Case Studies of the Application of the Contingent Ranking Methodology at Mesa Verde and Great Smoky Mountain National Parks. Prepared for the Electric Power Research Institute. October.

Stopher, P. 1976. "Derivation of Values of Time from Travel Demand Models." Transportation Research Record 587.

Wilman, E.A. 1980. "The Value of Time in Recreation Benefit Studies." Journal of Environmental Economics and Management 7: 272-286.