# Benefit Estimation Goes to Court:
# The Case of Natural Resource Damage Assessments

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# BENEFIT ESTIMATION GOES TO COURT: THE CASE OF NATURAL RESOURCE DAMAGE ASSESSMENTS

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## 1. Introduction

Under administrative law the judicial system acts as a gatekeeper, evaluating the rule making process. As Stewart [1975] noted, the focus of these evaluations has shifted from preventing unauthorized intrusion on private decision making to assuring that all interests are fairly represented in the agencies' exercise of their legislative mandates. Until recently, judicial reviews of environmental regulations have not permitted agencies much latitude in implementing their mandates with recognition of the benefits and costs of proposed regulations. Indeed, Melnick's [1988] recent evaluation of the evidence indicates that despite demands for "synoptic" decision making,[1] the Washington, D.C. Circuit (in several important decisions taking place in the late 1970's and early 1980's) "... created a legal presumption against use of cost-benefit analysis--or any other consideration of cost--in many forms of standard setting" (p. 33). While recent decisions may indicate a change (see Wald [1986]), Melnick calls for caution in interpreting their implications because a high level of consistency across court decisions is not likely to be realized under any set of interpretations of the courts' role in the rule making process.

This reluctance to consider benefit-cost information has changed for a new and potentially important class of environmental cases that do not involve

agency rule making. Nonetheless, they do involve agencies and states in cases relating to the quality of natural resources. Moreover, they assign a special role to the Department of Interior (DOI), which has prepared guidelines and models for the preparation of estimates of changes in the economic values of natural resources as a result of releases of hazardous substances.

This paper has three objectives: (1) to describe the economic analysis required by the legislation defining natural resource damage assessments; (2) to illustrate the judgmental questions that arise during an assessment using evidence from two recent cases, and (3) to consider the likely performance of the assessment process defined by the legislation and the implications for the course of research in resource and environmental economics.

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 and its re-authorizing amendments (SARA, 1986) establish two types of liability for releases of hazardous substances and oil.[2] The first of these, and the one that has received the greatest amount of attention, is associated with the liability of potentially responsible parties (PRPs) for the cleanup of old or abandoned sites containing these hazardous substances. This liability requires that the economic agents judged to be responsible for the release of hazardous substances posing some danger to human health and/or the environment be required to clean up the sites. The second type of liability concerns damages to natural resources and has received much less attention. It is the focus of this paper.

When oil or hazardous substances are released into the environment, human health may be adversely affected and the ability of natural resources to provide valuable services may be impaired. For example, the recreational services provided by a river (fishing, boating and swimming) may be reduced

through the accidental release of hazardous substances into the river. Natural resource damage is the value of the services lost from the time of the release to the point the cleanup activities cease plus the discounted present value of the lost future services due to a less than complete restoration of the river.[3]

When the release of oil or hazardous substances has led to natural resource damage, the trustee for the resource (most often state governments) seeks compensation in the courts from the responsible parties. The courts in turn must decide upon the size of the award by placing values on the lost service flows. This valuation involves a sequence of tasks including determination of the time of the release, quantification of the physical damage (i.e., changes in the physical characteristics of the resource), enumeration of the individuals affected by the reduced service flows, the values affected individuals place on these services, and appropriate rates to be used for capitalization and discounting.

## 2. The Law

CERCLA/SARA was originally designed as a cleanup program for old or abandoned sites containing hazardous substances or oil and for accidental releases of these materials from active sites.[4] This legislation also established an emergency fund (the Superfund) to pay for cleanup of substances released into the environment while the government seeks recovery of that cost from the responsible parties.[5] CERCLA/SARA imposes liability for the costs of cleanup on the responsible parties, along with additional liability for any damage the release of the hazardous substances may have caused to the natural resources involved.[6] The legislation also required the President to establish guidelines for the proper determination of the damages. These

guidelines have been promulgated by the Department of Interior (termed the DOI Rules). The rules have come under criticism and currently are the subject of a court case.

The CERCLA/SARA provisions include two important features influencing the ability to identify PRPs and the weight given to a trustee's estimates of damages.[7] First, the legislation provides for joint and several liability, thus enhancing the chances of legally identifying some entity as a PRP by establishing liability for any party involved, directly or indirectly, in the release of the hazardous substance. Second, an assessment of damage prepared following the DOI rules has rebuttable presumption. While legal scholars have debated the actual impact of rebuttable presumption, clearly this provision has influenced both the character of the DOI rules and the strategies adopted by trustees (see Yang et al. [1984]). Equally important, it appears to have influenced several PRP's evaluations of the relative costs of a settlement versus trial in natural resource damage cases.

### 3. Natural Resource Damage Assessments

To understand the economic issues associated with natural resource damage assessments, it is useful to review the guidelines for them specified in the DOI rules. These rules define the full sequence of activities, represented schematically in Figure 1, including the methods to be used in establishing injury, the linking of the release of the hazardous substance to the injury, and the determination of the damage (valuing the injury).[8] Because most natural resources provide services outside organized markets, assessment of these requirements necessarily draws on the current literature on methods for estimating nonmarketed resources' values.

The damage assessment begins when the trustee for each type of natural resource is notified (or recognizes) that a potential natural resource injury exists. Given notification, the rules first require assessing whether an emergency situation exists.[9] The burden of proof for establishing that emergency actions are warranted rests with the designated trustee.

Following notification, a pre-assessment screen is conducted.[10] During the pre-assessment screen, the trustee must determine what natural resources have been injured. Once they are identified, the pre-assessment process continues with examination of the perceived injury and determination of its importance vis-á-vis the cost of a full assessment. If the decision is made to proceed with a full assessment, the next step is to develop a formal assessment plan selecting the methodologies to be used in estimating natural resource damages. As part of the plan, the trustee must decide whether a Type A or Type B assessment is warranted and must notify the PRPs of the trustee's intention to perform an assessment.[11]

Determination of injury to a natural resource and subsequent determination of the injury's extent are tasks for natural scientists. Because information is costly and the resources available for its acquisition scarce, DOI rules require consideration of costs. Thus we can expect that uncertainty regarding both the exposure and extent of the injury will remain after the assessment is complete. Moreover, this uncertainty is incorporated into the damage estimates because the damage determination phase employs the scientific information as input to the economic analysis (an analysis similarly constrained by information and uncertainty).

The conceptual framework inherent in the DOI rules for the estimation of damages follows the idea of estimating the change in the value (arising from

direct use) of each natural resource as an asset. While there are some departures from that basic principle, this view remains the most consistent interpretation of the intentions of the DOI rule.

The rules propose a hierarchy of methods for measuring damages. The trustee must demonstrate that the assessment has selected the lower of the restoration or replacement costs and that the result has been compared with the estimated (future) economic damages associated with the release. In the event restoration or replacement is precluded, the preferred methods rely on market prices or on appraisal methodologies to estimate prices. The DOI rule requires that the change in the value of the resource be valued by the differences in market (or appraised) prices resulting from the release. When these avenues are not available, the rule specifies that nonmarket methods can be applied. While a sequence of methods are identified (including unit day value, factor income, travel cost demand, hedonic price, and contingent valuation methods), all are described as equally viable.

Damages arise from diminution in the quality and quantity of services provided by the resource. As a practical matter, the choice of methods will be dictated by the data available and by the unique features of the resource.[12] Regardless of the methods chosen by the trustee, the analyst must define the equivalent of the extent-of-the-market for each resource. This process requires recognition that a resource may support multiple competing uses.

Once the trustee has estimated the damages for each service provided by the resource, the total damage claim must reflect the intertemporal aspects of the damage. The PRP is liable for the damages that have occurred from the

time of the release to the present and for any residual damage that will carry over into the future.

## 4. Damages and the Courts

The estimation of natural resource damages under CERCLA/SARA is a relatively new enterprise with which we have limited experience. To our knowledge, there have not as yet been court decisions under the statutes and DOI rules governing natural resource damages. Moreover, litigation practices limit the extent of information available from the plaintiff and defendants involved in each case.

Nonetheless, even a partial review of the experience illustrates the economic issues involved. Our summary is confined to two cases for which a sufficient component of the research conducted by each side was available for summary.[13] Both of the cases were initiated before the final DOI rule for Type B assessments were issued.

### The Eagle Mine Case: Plaintiff's Damage Analysis

The first case involves the Eagle Mine facility near Gilman, Colorado. In this case the plaintiff/trustee (i.e., the state of Colorado) contended that operation of the Eagle Mine resulted in release of a variety of hazardous substances into the groundwater and the Eagle River, and may have affected some portions of public land adjoining the river. These effects arose primarily from the disposal of mine tailings.

As a direct result of the release, the trustee contended, several services provided by the Eagle River diminished both in quality and quantity. These services generally related to recreational activities, including fishing

and boating and nonwater-based activities such as hiking and camping. Moreover, because of these releases in the river, the plaintiff argued, its aesthetic quality had been impaired, leading to a decline in the value of properties adjacent to the river. Finally, some private wells used for drinking water were thought to have been contaminated.

To evaluate the natural resource damages associated with these effects, the trustee used three methods. Estimates were developed using Forest Service estimates of the values per day of alternative recreational experiences ($14 per day for water-based recreation and $9 per day for nonwater-based), two contingent valuation surveys, and a hedonic property value model. The information necessary to undertake the above analyses was drawn from two mail surveys containing questions regarding recreational use, property values, and willingness-to-pay to clean up the damaged portions of the Eagle River. One survey was administered to the residents of Eagle County, while the second was sent to a sample of Colorado residents.[14]

Two different methods were used to estimate the use-related values lost because the mine releases affected a section of the Eagle River. The first of these used unit day values (adjusting for the length of "typical" days) estimated by the Forest Service for water and nonwater-based activities along with the results of contingent behavior questions from the surveys. These questions asked how many days a respondent typically would spend in water and nonwater activities (with each asked separately) in the relevant section of the river if it were restored to its "pre-mine condition" and had water quality comparable to sections above the mine. Comparing these responses to previous year's days-of-use indicated by these same individuals and to estimates of per capita use from the 1980 Colorado State Comprehensive Outdoor Recreation Plan,

an estimate of incremental use for water and nonwater activities was prepared. The results are given in Table 1. An estimate of the aggregate damage occurring in Eagle County was computed by multiplying the per-person values for use increments by the number of individuals over 18 years of age living in Eagle County. This estimate was then projected forward for ten years and discounted back to 1985 using a 10 percent discount rate. Similar procedures were employed to determine the damages outside Eagle County (i.e., the rest of Colorado).

The second approach employs an ex ante perspective (see Smith [1987]) and includes both use and nonuse values. This approach was based on contingent valuation questions in the Eagle County and State of Colorado surveys, eliciting respondents' willingness-to-pay (WTP) for Eagle River cleanup. In the Eagle County survey respondents were asked their willingness to make an annual payment for each of ten years to clean up the relevant section of the Eagle River. In the State of Colorado Survey respondents were asked their annual willingness-to-pay over ten years to clean up all possible problem hazardous waste sites in Colorado.[15] The number of these sites was suggested to be over 200. Following this response, seven sites were identified as involving current legal action. Brief descriptions of each site were provided. Then, each respondent was asked to perform two allocations:

(a) specify from a schedule of percentages (incremented in units of 10 percentage points) the percent of their total bid for all sites that would be assigned to the seven sites;

(b) identify a most important site and the percentage of the amount designated for the seven sites (in response to the question described in part (a)) to be allocated to this most important site.

In addition, respondents were asked to allocate their total bid (for cleanup of all 200 sites) among reasons (again by specifying percentages) that were interpreted as reflecting use and nonuse values. The estimates for Eagle River correspond to the average of the allocated total value for those individuals identifying the Eagle River as the most important area.[16]

Table 1 details the results of the contingent valuation analysis. In the Eagle County survey the questions were designed in such a fashion that WTP estimates would include both use and nonuse values, but the difference between water-based and nonwater-based values could be identified. In the State of Colorado survey no differentiation between water- and nonwater-based values was possible, but an allocation between use and nonuse values was made.

The mean estimates of annual WTP derived from each survey are displayed in Table 1. In the case of Eagle County residents, the annual WTP estimates are multiplied by 6063 households, carried forward for ten years assuming a population growth of 2 percent, and then discounted back to 1985 at 10 percent. A similar aggregation procedure is employed for the statewide estimates.

The final analysis conducted by the plaintiff was a hedonic property value study. The hedonic model was estimated using responses to the survey of Eagle County residents who answered a question about the purchase price for their homes and who were also within 25 miles of the Eagle Mine. A dummy variable indicating whether the home was within 6 miles of the mine was used to gauge the effects of the mine.

The hedonic model's objective was to obtain estimates of damage due to possible contamination of local drinking water supplies and to blowing dust from the Eagle Mine tailing piles. Unfortunately, the hedonic technique

captures all aspects of this proximity to the Eagle Mine. Moreover, since the differences in property values due to proximity to the Eagle Mine represent capitalized differences in the flow of services from the injured natural resources, the hedonic model results represent the present value of perceived future damages.[17]

Table 1 also displays the results of the plaintiff's hedonic property value study. The results suggest that property located within 6 miles of the Eagle Mine is worth $24,000 less than comparable property located beyond the six-mile limit. Because there were 500 residences located within the 6 miles, the plaintiff claimed an aggregate damage estimate of $12 million.

The plaintiff's estimates of natural resource damages were not intended to be added across methods. Rather, they are alternative damage estimates with some overlaps in the methods' coverage of the resource's services. None of the methods captures all of the services. For example, one might argue that the recreation damages should be reflected in the contingent valuation estimates for the corresponding user groups, and that the hedonic values should reflect both use and some nonuse values (see Smith [1985]).

Table 1 also includes estimates of the damages. To estimate these past damages, the plaintiff assumed that damages began in 1951. Losses were appreciated using a capitalization rate of 2.5 percent for damages from 1951 through 1975 and 10 percent for those occurring from 1975 to 1985. In addition, population was estimated to have grown by 2.5 percent per year between 1951 and 1975 and 1.67 percent thereafter. Using only the damage estimates derived from the recreation unit day method, the plaintiff estimated past damages to be $50.8 million.

**The Eagle Mine Case: Defendant's Damage Analysis**

It is probably not surprising that the natural resource damage estimates compiled by the defendant's group were considerably less than those produced by the plaintiff. However, what is somewhat surprising is the close correspondence between both sides' estimates of the unit value estimates. The large differences in the total damage estimates arise from differences between the plaintiff's and the defendant's estimates of the number of individuals (or households) judged to have been damaged, as well as from the substitution possibilities available for the services of the affected natural resource.

Based on the technical description of the exposure and injury as well as on engineering reports evaluating the Eagle River site, the defendant's analysis focused on the implications for recreation and drinking water supplies of releases from the mine and tailings ponds. Valuation estimates were confined to use values.

The recreational damage analysis separated water- and nonwater-based activities. In each case it was assumed that the portions of the river above and below this stretch were not injured and that these portions provided services identical in quality and quantity to those that would be provided by the injured stretch if it were to be fully restored. These unaffected portions were treated as perfect substitutes for the water- and nonwater-based recreational services provided by the injured resource. With this assumption, the defendant's analysis treated the recreational damage caused by the Eagle Mine activities as the consumer surplus loss associated with the increased travel cost incurred by recreationists using the substitutes for the injured stretch (10 miles for every round trip). Using the 1980 Fish and Wildlife Survey, the defendant estimated a travel cost demand model for individuals

traveling from around the country to fishing sites in a five-county region surrounding the Eagle Mine Complex. The defendant's analysis defines the baseline conditions as those corresponding to the sections above and below the 5 miles involving the mine. It is therefore approximately comparable to what the plaintiff used in wording the contingent behavior questions that formed the basis for this analysis of use values. The assumption of perfect substitution allows the change in resource availability due to the mine to be treated as a price increase. Damages were estimated as the average consumer surplus loss from that price increase. The estimated consumer surplus per trip based on the defendant's model was approximately $21, a figure that actually exceeds the estimates adopted by the plaintiff (in constant dollar terms). However, the assumption that perfect substitutes are available (above and below the affected area) implies that the incremental loss in consumer surplus is the relevant measure. This was about $1.35.

The travel cost model was also used to predict the reduction in trips per capita attributable to the increased travel cost. The reduction in total trips was derived by scaling the predicted trip rates by the relevant population. This population was specified using Colorado data describing the average number of fisherman per mile of river in the state, and then attributing this figure to the injured five-mile stretch of the Eagle River. The defendants found that the lost fishing days due to the increased travel cost and their definition of the relevant population amounts to $4,000 for 1985. As reported in table 2, the discounted present value of past and future water-based damages amounts to approximately $78,000.[18]

Damage estimates associated with lost days of nonwater-based recreation were estimated in a similar fashion. The average consumer surplus associated

with nonwater-based activities was estimated to be approximately $32. With the same perfect substitution assumption, the estimated loss becomes $.55. The defendant estimated the relevant population to be 1000 individuals who spend an average of 10 days per year engaged in nonwater-based recreation, leading to the $5000 annual estimate and present value of past and future damages or $104,000 in Table 2.[19]

No attempt was made by the plaintiff to focus directly on drinking water effects. In contrast, the defendant explicitly considered the drinking water issue, using the cost of supplying alternative sources of drinking water in the case of private wells and remediation of municipal supplies through filtration. The annual cost of this filtration was estimated to be $7,500 and the discounted present value was estimated to be $47,000. The defendant's experts concluded that only one private well actively used for drinking water was contaminated and that bottled water would be an adequate substitute for that well. The annual cost of providing bottled water to a single household was estimated to be $720, with a present value of $14,000.

The defendant estimated the total natural resource damage, both past and future, caused by the Eagle Mine to be approximately $240,000. The plaintiff estimated past damages to be $50.8 million and future damages to range from $15 to $45 million. Using the most conservative future damage figure, the plaintiff's total estimate was over $65 million.

**The Idarado Mine Case: Plaintiff's Damage Analysis**

Our second case also involves a mine in Colorado. The Idarado Mining and Milling site became a natural resource damage case with the discovery of hexavalent chromium in 1978 in two new municipal water supply wells drilled

for the town of Telluride. The wells were located about 1,600 feet west of the largest tailings pond for the Idarado complex. The state of Colorado is again the trustee for the affected resources.

As with the Eagle Mine Case, the Idarado case produces overlapping estimates of natural resource damages to an aquifer, the Uncompahgre River, the Ridgeway Reservoir, and to land (as a result of blowing tailings and locations of tailing piles). Because the statewide survey employed in the Eagle Mine case included the Idarado mine site as one of the seven sites identified to each respondent as part of the requested allocation of total bids for cleaning up existing problems at all sites, the trustee used the results from the state survey for those households identifying the Idarado as the most important site.

The plaintiff's analysis used these contingent valuation estimates to measure the total past and present natural resource damages caused by the activities of the Idarado Mine. These were defined to correspond to the changes respondents perceived would take place if all sites were "cleaned up." The contingent valuation estimates for past and future use and nonuse value are given in Table 3. The values per household are consistent with those presented in Table 1 for the Eagle Mine case. They indicate the present value of future use and nonuse damages of over $40 million and past use damages in excess of $100 million.[20]

To support these estimates the plaintiff's evaluation also reported values using other techniques to estimate components of damages associated with specific aspects of the affected natural resources. These estimates relate to groundwater and soil contamination and to lost recreational fishing. A service replacement method was employed to estimate the damage to the

drinking water aquifer, a property value appraisal approach for soil contamination, and a unit day method for losses involving recreational fishing.

Damage to the aquifer supplying a portion of the drinking water to the town of Telluride, Colorado was determined by using the estimated cost of a surface water treatment plant. Estimates of the total costs of this facility ranged from $1,000 to $3,000 per acre foot supplied per year. Multiplying the per-acre-foot price by the estimated demand on the system and then discounting it over 30 years at 10 percent produced the plaintiff's damage estimate of $3 to $5 million reported in Table 3.

Examination of the soil in and around the town of Telluride revealed elevated levels of lead and cadmium. The damage associated with soil contamination was estimated by using the decreased property values arising from homeowners' knowledge of the contamination.[21] Because no market information was available for Telluride, a case of soil contamination in the town of Park City, Utah was used. Local real estate appraisers estimated the decline in property value due to the contamination as 10 to 15 percent for both residential and commercial properties.

The plaintiff's analysis estimated that 50.9 acres of residential and commercial real estate in Telluride contained or was in close proximity to contaminated soil. Using current estimates of the market value for this property and the appraisers estimates of loss, the present value of the damages was estimated to be $2 million.

The Bureau of Reclamation is completing a dam on the Uncompahgre River that will eventually lead to a lake of approximately 1000 surface acres. Because the Uncompahgre River was argued to have been contaminated by the

Idarado Mine, the waters of the new lake would not support high quality game fish (i.e., trout). Using Forest service estimates of unit day values for a trout fishing day ($14-22 per day) and the Bureau of Reclamation estimate of 16,000 additional fishing days if the reservoir were not contaminated, the trustee estimated lost recreational fishing at $.9 to $1.4 million in present value terms.[22]

**The Idarado Mine Case: Defendant's Damage Analysis**

The defendant's estimates of natural resource damage are provided in Table 4. These estimates relate only to the damage categories specifically associated with the contaminated aquifer and soil, as well as to those related to lost recreational fishing.[23] The defendant argues that because least-cost alternatives are required by CERCLA, the damage due to the contaminated aquifer corresponds to the cost of drilling new wells, $205,000. Following similar logic, the defendant's estimate of damage due to soil contamination assumes that the injurious affect of the contamination can be overcome by covering the affected areas with 6 inches of uncontaminated soil and planting grass. This procedure is estimated to cost 27 cents per square foot resulting in a total cost (damage) of $275,400.[24]

With reference to the lost recreational fishing in the Ridgeway Reservoir, the defendant's analysis argued it would be inappropriate for the state to seek damages for a nonexistent fishery that was never planned to exist. However, if the fishery were to exist and if 16,000 fishing days were spent at the reservoir per year, the defendant claims that the value per fishing day would not be $14 to $22, but would reflect the marginal value that Colorado fisherman would place on the improved reservoir fishing. Using estimates for

improved recreational fishing along the Uncompahgre River that amount to $.07 per day (this low because of the available substitutes), the defendant estimated damages as $14,000.

Thus, in summary, the defendant's estimates of future damages were less than $500,000. In contrast, the plaintiff estimated future damage to range from $8 million (based upon the individual damage category estimates) to over $40 million (based upon the contingent valuation method), and estimated past damages to be in excess of $100 million.

**Damage Estimate Reconciliation**

It is certainly not surprising to find disparate damagae claims in the adversarial setting of a court case. However, in these cases we find estimates differing by at least two orders of magnitude. Moreover, in the Eagle River Case, the definition of baseline conditions is approximately comparable between plaintiff and defendant's analyses. If both sets of estimates are equally plausible, then these discrepancies would serve as rather severe criticism for the state of the art in nonmarket valuation. Fortunately (for economists), this inference is not the correct one to draw from the results we have summarized. Discrepancies can be explained primarily by assumptions made without benefit of any analysis to justify them. Indeed, the estimates that can be compared are remarkably close. The discrepancies that do exist arise from differences in each side's assumptions.

The greatest difference in estimates between plaintiffs and defendants is found in estimates of past damage. The most important source of disparity in past damage estimates is the time period over which past damages are accrued. The plaintiff in both the Eagle and Idarado Mine cases starts the accrual of

damages in 1951, while the Eagle Mine defendant begins in 1981 and the Idarado defendant simply assumes that there were no past damages. These differences in time horizons explain the majority of divergence in the damage estimates, and are not a reflection of the benefit estimation techniques employed. Instead, they arise from the assumptions generally supplied by the plaintiff's and defendant's counsel to the experts retained to estimate the damages.[25] If we subtract the estimates of past damage from the totals, the disparity is reduced considerably. In the Eagle Mine case the plaintiff's estimate reduces to $65 million, and in the Idarado the plaintiff's estimate falls to $41 million.

Considering now the disparity in the estimates of present and future damage, we do find substantive differences in assumptions and what is included in the damage estimates. For those cases in which comparable "commodities" are valued, the estimates are remarkably close. For example, for the Eagle Mine case, the two sets (plaintiff and defendant) of per-unit estimates fall within the range found in the literature. Moreover, both defendants' estimates of recreation values lost per unit of use exceed those of the plaintiff -- $21 per day versus $14 per day for water-related activities and $32 versus $9 for nonwater-related activities. The discrepancies in these respective aggregate estimates arise from the plaintiff's assumption that the full value of the experience would be lost and in the assumption of the number of people experiencing gains with restoration. In our view neither side was completely correct. While the defendant did document the physical availability of substitutes, these substitutes do not appear to have been reflected in the demand model. Similarly, the contingent valuation approach examined the increment to use arising from cleanup but attributed the full value to that

increment. It did not attempt to distinguish transfers from higher cost or lower quality alternatives and net new use. The former group would not be valued at the full per-unit consumer surplus estimate.

The plaintiff considered the relevant market for the recreational services provided by the river to extend to the state of Colorado, whereas the defendant limited the market to local residents considered (by a simple ratio) to be fishermen. This "extent of the relevant market" issue was identified as a potentially important influence to recreational demand models some time ago.[26] Recently, it has received renewed research attention.[27] While the assumed extent of the market can influence estimates of the shape of the demand function (the primary question raised in the recent research), the key issue for aggregate damage estimates is the number of people experiencing the losses. In short, even a small difference in the value placed by one household on a recreational experience can lead to a large divergence if multiplied by vastly different numbers of households.

The difference in recreational damage estimates for the Idarado case arise from a similar issue concerning the relevant "price" or value attached to improvement of the resource. Does the value relate to newly created fishing days or to new supply opportunities for fishing? Clearly they are not the same. In this case the defendant's analysis conceded (for the sake of argument) that stocking the Ridgeway Reservoir with trout might lead to some 16,000 annual fishing days experienced at the reservoir. The issue raised by the defendant is the appropriate value to assign to these days. The defendant argued that Colorado has a large number of excellent trout fishing sites and that adding still another will not induce more fishing days but merely reallocate existing days. The relevant value is the gain realized from these

reallocations (and potentially a small number of net new days). While the value to a fisherman of a trout fishing day may well fall in the range cited by the plaintiff ($14-22), this is not the same as the values generated by adding more fishing opportunities.

The Eagle Mine case provides another example of how differences in modeling strategy can cause defendant and plaintiff to value different "commodites." In this case, effects on an aquifer were involved. The plaintiff argued that damages to drinking water supplies can be captured by the hedonic property value model, whereas the defendant used the cost of remedial activity (i.e., additional filtration in the case of municipal water supplies, and replacement with bottled water in the case of contaminated private wells). There are a number of good reasons to expect these estimates to be quite different. First, the hedonic approach, even if the distance threshold were reasonable, cannot isolate that portion of the property value decline due to the contaminated water supply. Second, the defendant's method assumes that filtration and bottled water are perfect substitutes for the contaminated sources of drinking water. This is simply not true. Convenience alone distinguishes the tap water/bottled water comparison. Even with filtration, all the services of the aquifer are not restored.

To this point we have explained a large component of the differences in future benefits without considering the treatment of nonuse values. Plaintiffs have included them and defendants have not. While the DOI rules exclude them (except when use values cannot be measured), this position is not the correct economic approach. Nonuse values are relevant to the change in the value of a natural resource due to these types of releases. When they are omitted, we should expect differences.

Thus, much of the disparity in the (future) damage estimates for these cases is due to unsubstantiated maintained assumptions about who will gain. To correct this situation would require analyzing the extent of the market. Neither side in these cases did that. Further sources of differences can be found in judgments made on the availability of substitutes for the affected resources and on what services would be provided by restoring a natural resource to its baseline conditions. Indeed, once these maintained assumptions are considered, the damage estimates can be reconciled. The fact that problem areas involving these types of assumptions exist does not invalidate natural resource damage assessments. However, it does suggest that the level of economic expertise available to judges to evaluate the "facts" of each side's evidentiary claims will probably need to exceed what many analysts of judicial behavior have argued can be expected (see Cicchetti and Haveman [1988] and Wald [1983]).

## 5. Implications for Research

It is difficult to gauge what positive effects natural resource damage liability will have on the development of the economic theory of resource valuation. Statutory mandates presented by CERCLA and SARA require that the techniques used to value the services of nonmarketed resources be developed to a new level of specificity. Often what is involved in these analyses is an evaluation of changes in the quality of a resource, of the risks households might experience from a release, or in the resource's ability to provide a subset of all the possible services that could have been available from the resource in its unimpaired state.

As presently written, the statutes and DOI rules have assumed that the information necessary to meet the demands of complex valuation tasks is already available and that estimates for the values of resource services are available in the literature. This is only partially true. We are only now beginning to accumulate experience with these techniques and to understand what portion of observed differences in valuation estimates are due to differences in the features of (and the services provided by) the resources involved, as compared to assumptions and judgments made in implementing the models used to obtain the estimates (see Smith and Kaoru [1988]). Two tasks would seem especially desirable to avoid wasteful and unproductive debate in the responses to the CERCLA/SARA mandates. First, we should evaluate what we know and, equally important, what we don't know about the state of our conceptual, methodological, and empirical information on the value of natural resources as assets providing diverse services that directly and indirectly support a wide range of utility-generating activities. Second, we should use this precis to formulate a reasonable set of protocols for responding to the requirements for natural resource damage assessments. This must be sensitive to what we don't now fully understand and incorporate mechanisms to update and revise procedures as our knowledge base grows through experience.

Without both, the process of performing natural resource damage assessments and settling them (whether in or out of court) is likely to waste scarce research resources in resolving the needless polarization in the evaluations.

Figure 1

**NATURAL RESOURCE DAMAGE ASSESSMENT PROCESS**

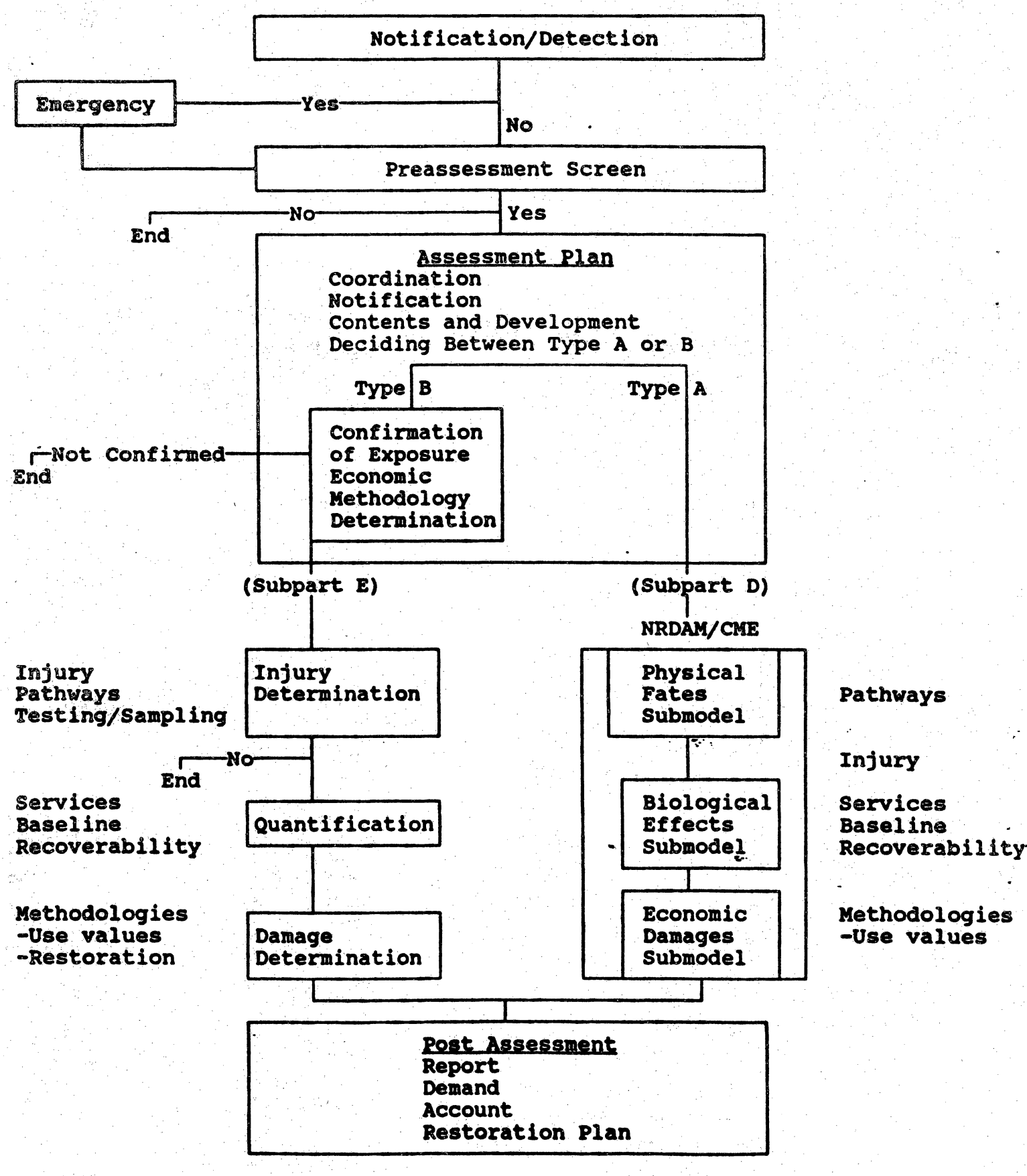

**Table 1. Plaintiff's Natural Resource Damage Estimates: Eagle Mine Case**

| Estimation Method/ of Damage | Unit Damage Estimate 1985 Dollars | Discounted Present Value of Future Damage Type (aggregate estimate) |
|---|---|---|
| **Future Damages** | | |
| **Unit Day Method and Contingent Behavior** | | |
| Water-based Recreation | $14 per day | Eagle County Residents<br>$ 2.0 million |
| | | Non-Eagle County Residents<br>$ 6.3 million |
| Nonwater-based Recreation | $9 per day | Eagle County Residents<br>$ 1.0 million |
| | | Non-Eagle County Residents<br>$6.0 million |
| **Contingent Valuation** | | |
| **Eagle County WTP Survey** | | |
| Use and Nonuse values (water-based) | $73 per yr./ household | County Residentsa<br>$3.4 Million |
| Use and Nonuse values (nonwater based) | $30-51 per yr./ household | County Residentsa<br>$1.5 Million |
| **State of Colorado WTP Survey** | | |
| Use values | $1.80 per household | State Residentsb<br>$15 million |
| Nonuse values | $3.80 per household | State Residentsb<br>$30 million |
| **Hedonic Property Value** | $24,400 per household | 500 Local Residents<br>$12.2 million |
| **Past Damages** | | |
| Water and Nonwater Recreation | | Eagle County Residents<br>$9 million |
| | | State Residents<br>$41.8 million |

Source: Information in this table was drawn from Rowe et al. [1985]. Some adjustments to the original Rowe et al. data have been made for comparability purposes.

Notes: a) 6063 households in Eagle County.
b) 1.2 million households in Colorado.

**Table 2. Defendant's Natural Resource Damage Estimates: Eagle Mine Case**

| Estimation Method/ Type of Damage | Unit Damage Estimate 1985 Dollars | Discounted Present Value of Future Damage (aggregate estimate) |
|---|---|---|
| **Future and Past Damages** | | |
| **Travel Cost Method** | | |
| Water-based Recreation | $1.35 per day | 142 Days Lost Per Yr.<br>$78 thousand |
| Nonwater Based Recreation | $.55 per day | 1000 Recreationists<br>$104 thousand |
| **Service Replacement Method** | | |
| Municipal Filtration | $7,500 per year | Municipal Water Dist.<br>$47 thousand |
| Private Wells | $720 per year | One Private Well<br>$14 thousand |

Source: Information in this table was drawn from National Economic Research Associates [1985]. Some adjustments to the original NERA data have been made for comparability purposes.

**Table 3. Plaintiff's Natural Resource Damage Estimates: Idarado Mine Case**

| Estimation Method/ Type of Damage | Unit Damage Estimate 1985 Dollars | Discounted Present Value of Future Damage (aggregate estimate) |
|---|---|---|
| | **Future Damages** | |
| **Contingent Valuation Method** | | |
| Use Values | $26 per household | County Residents $.22 million |
| | $1.80 per household | State Residents $13 million |
| Nonuse Values | $42 per household | County Residents $.36 million |
| | $3.80 per household | State Residents $28 million |
| **Service Replacement Method** | | |
| Aquifer Contamination | $2,000 per yeara | Town of Telluride $3-5 million |
| **Property Value Appraisal** | | |
| Soil Contamination | b | 51 Acres $2 million |
| **Unit Day Method** | | |
| Recreational Fishing | $14-22 per day | 16,000 user days $.9-1.4 million |
| | **Past Damages** | |
| **Contingent Valuation Method** | | |
| Use Values | $26 per household | County Residents $1.9 million |
| | $1.80 per household | State Residents $104 million |

Source: Information in this table was drawn from Boland and Milliman [1986]. Some adjustments to the original Boland and Milliman data have been made for comparability purposes.

**Table 4. Defendant's Natural Resource Damage Estimates: Idarado Mine Case**

| Estimation Method/ Type of Damage | Unit Damage Estimate 1985 Dollars | Discounted Present Value of Future Damage (aggregate estimate) |
|---|---|---|
| | **Future Damages** | |
| **Service replacement method** | | |
| Aquifer Contamination | $205,000 per new well | Town of Telluride $205,00 |
| Soil Contamination | $11,700 per acre | 30 Acres $275,400 |
| Recreational Fishing | $.07 per day | 16,000 user days $4,500 |

Source: Information in this table was drawn from d'Arge [1986]. Some adjustments to the original d'Arge data have been made for comparability purposes.

## Notes

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1. Shapiro [1986] described synoptic decision making as a process that involves assembling the relevant facts, alternatives under evaluation, assigning priorities, and selecting that alternative that best achieves the valued outcome, given the information at hand.

2. In this paper we often delete explicit reference to oil, but the reader should bear in mind that CERCLA/SARA treats oil in a manner symmetric to its treatment of hazardous waste.

3. If the river was restored through cleanup efforts to its original pre-release state, the amount of natural resource damage would be equal to the capitalized stream of the lost services. Since the river was fully restored, there would be no diminution in future service flows. However, if restoration is less than complete, future damage will occur and the PRP is liable for the value of this damage. Thus, it should be borne in mind that the magnitude of the damage liability is linked to

the cleanup liability, since the chosen level of cleanup activity will in large part determine the residual resource damage.

4. CERCLA/SARA also has jurisdiction over oil spills both on and off shore.

5. There are four different types of cleanup actions under CERCLA. The first of these involves direct EPA cleanup of a site under section 104. Following cleanup, EPA can seek recovery of the costs from a responsible party under section 107 of the legislation. A second cleanup action can involve EPA mandating cleanup undertaken by the responsible party under section 106 of the legislation. It is also possible to have a private party not specifically involved in the release of the hazardous substance to undertake cleanup and cost recovery made using the fund under section 112 of the legislation. This same type of action can be undertaken against the PRP under section 107. Because each of these actions is intended to reduce the health risks associated with the hazardous substances, they are viewed as completed when a cleanup standard has been realized.

6. The term natural resources means "land, fish, wildlife, biota, air, water, ground water, drinking water supplies, and other such resources belonging to, managed by, held in trust by, appertaining to, or otherwise controlled by the United States, any State of local government, or any foreign government, any Indian tribe, or, if such resources are subject to a trust restriction on alienation, any member of an Indian tribe." CERCLA section 101.

7. SARA changed and modified CERCLA in six important ways. First, SARA strengthened the rebuttable presumption provisions by extending them from federal to state trustees. Second, a clear identification of trustees was provided. Third, coordination between cleanup activities and the collection of data for the assessment of natural resource damages was required. Fourth, the statute of limitation was extended. Under SARA the statute of limitations expires three years from the latest of three possible events, (1) the discovery of the release of a hazardous substance; (2) the promulgation of the final natural resource damage assessment regulations by the Department of Interior; or (3) the completion of remedial cleanup actions at hazardous waste sites. Fifth, damage awards could be made available to the trustee without a federal appropriation. Finally, the symmetric treatment of cleanup costs and natural resource damages was eliminated, thus prohibiting claims against Superfund for natural resource damages or the preparation of damage assessments.

8. For damage to exist, a physical link between adverse changes in the chemical, physical quality, or the viability of the resource and the discharge or release of oil or hazardous substances must be established. Once this link is established, the extent of the injury is quantified and the monetized value of the injury determined.

9. An emergency is defined as any case in which the discharge or release required immediate action to avoid irreversible losses of natural

resources or to prevent or reduce continuing danger to existing natural resources.

10. The screening considers the likely costs of such an appraisal in relationship to the benefits associated with the overall process. The DOI Rules characterize this step as a "desktop" review of existing data (with minimal field work), which they assume can be completed in a matter of a few days.

11. Type A assessments are cases involving routine evaluations, typically small spills. A computer model has been developed under DOI support to estimate damages when these spills take place in marine or coastal environments (see Grigalunas and Opaluch [1988] for details). Type B assessments are the primary focus of our discussion. They require individualized evaluations and are the primary focus of the DOI rules.

12. The rules seem to have been written under the assumption that models and specific estimates of the values of services from the different types of resources involved in assessments are available. There is an admonition on costs comparable to that identified earlier for injury determination.

13. Summarizing the experience with estimating natural resource damages is a difficult task in any setting. Doing it as part of a court case is worse. The information we used for the two cases described here comes from different stages of the two cases. The Eagle River Case has been

settled without a court decision. Our analysis relates to the analysis prepared by plaintiff and defendants as of the end of 1985. The plaintiff's analysis was updated and refined from that original submission. These changes did not alter the overall nature of the analysis available to us. There may have been refinements in the defendant's analysis, but this was not available to us.

To our knowledge the Idarado Case is in process. Our summary is based on the plaintiff's submission as of November 14, 1986 and the defendant's review and analysis submitted December 21, 1986. It is our understanding that further work is underway on both sides but this has not been available to us.

14. The surveys did not contain identical questions.

15. Formulation of the questions on both surveys was consistent with interpreting the estimates as an option price (see Graham [1981] and Smith [1987] for discussion). We use the WTP description here to emphasize that the questions were posed in a format specifying that individuals would be required to pay for the improvement rather than compensated for the damage.

16. In constructing total values, these estimates were separated according to whether a respondent was a resident of Eagle County. Those respondents living outside the county had their estimates scaled by one-half to reflect the potential for overstatement among individuals not familiar

with a good or service. The specific adjustment was made based on findings from laboratory experiments.

17. This distinction is also relevant to the selection of a discount rate because equilibrium price schedules in the housing market reflect each individual's internal rate of time preference. Consequently, it is important to consider how these values are used and compared with asset values estimated as a present value of a stream of benefits from a resource using a different discount rate. Moreover, the prices used in the stated purchase price are converted into current dollars using the consumer price index.

18. The defendants calculated past damages beginning in 1981. Past damages are not capitalized forward, but future damages are discounted to the present at a 6.9 percent rate.

19. Of the 1000 individuals, 500 live in the immediate area (total population is 1000) and 500 were assumed to be nonresidents.

20. The trustee presents estimates of past damage only for lost use value. The present value of future damages was obtained by discounting a 10-year stream of annual losses (the annual household value times the number of households) at 10 percent. The capitalization of past damages followed the method employed in the Eagle Mine case and assumed the initial injury to have occurred 31 years ago and employed a 2.5 percent capitalization factor from 1956 to 1975 and a 10 percent rate from 1975 to 1985.

21. This argument maintains that the market perfectly capitalizes good or bad information affecting the relevant homes as assets.

22. These estimates were questioned because the Bureau of Reclamation's original benefit cost analysis did not include fishing recreation as a benefit from the reservoir on grounds that stocking would not be economical. Nonetheless, the Bureau did indicate that public pressure could force some type of stocking. This was used to support the plaintiff's conclusion of these losses.

23. The defendant claimed that the estimates presented by the plaintiff based upon the contingent valuation method, were invalid because of inaccuracies in the statewide survey and incorrect interpretations of the survey results by the plaintiff. The defendant's review also argued that the questions posed in the survey were vague with respect to the injury that was to be valued. Therefore the respondents did not necessarily share the same perception of the injuries.

24. In both of these cases the defendant's analysis argued that neither component of damage was relevant for natural resource damages. The first because the drinking water supplies met federal standards, and the second because private land was involved. We have specifically addressed these criticisms in the text because neither analysis is correct. The contaminated water is covered under CERCLA, but neither group's estimates reflect the services involved--which are not current

drinking water needs. In the case of the blowing tailings, these would also be covered, but the property value approach selected is not sufficiently discriminating to capture the effects involved.

25. While it is true that different discount rates and capitalization factors were employed by the plaintiffs and defendants and these differences could be interpreted to reflect differences in economic estimates, their impact on the past damage estimate is small in comparison to the time frame disparities.

26. An example of an attempt to determine empirically the extent of a recreational market can be found in Smith and Kopp [1980].

27. For a discussion of these new models, see Bockstael et al. [1987].

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