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# Is the Seriousness of an Environmental Loss a Matter of What Caused It?

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**ABSTRACT**

Environmental losses, each described along with its cause, were judged for seriousness. Four types of cause were studied: illegal behavior, carelessness, economic and population growth, and natural events. Environmental losses were considered most serious when caused by illegal behavior or carelessness, and only slightly less serious when caused by growth. Losses due to these three types of human causes were considered much more serious than when the same losses were caused by natural events. Naturally caused environmental losses were probably considered least serious because they do not provoke the sense of violation or responsibility commonly associated with human-caused losses, and because naturally caused losses are often considered unavoidable and in the natural scheme of things.

Key words: human and natural causes, environmental loss, paired comparisons, reliability

# Is the Seriousness of an Environmental Loss a Matter of What Caused It?

## INTRODUCTION

If something privately owned such as an automobile is insured for a specific value and is damaged or destroyed through no fault of the owner, the insured value and thus the payout to the owner is typically the same regardless of the cause of the loss. For example, the payoff for loss of the automobile typically would be the same whether the cause was a traffic accident, a garage fire, theft, or hail. Generally, how much the lost object was worth does not depend on what caused its loss. We would think that a similar principle would hold for environmental losses. For example, the value of a stand of trees lost to fire should probably not differ whether the loss was caused by a careless camper or by an arsonist. Or the value of a lost herd of elk should probably not differ depending on whether the elk died because of poaching, because of an unusually harsh winter, or because of disease.[1]

Yet it is becoming increasingly clear that people's evaluations of losses—including their judgments of the importance or seriousness of the losses, and of the appropriateness of injured parties receiving compensation for the losses—are affected by more than just the magnitude or consequences of the loss (see Baron, 1993). Chief among the other influences is the cause of the loss.

Three studies have documented the effect of cause in evaluations of environmental losses. Each evaluated how natural as opposed to human causes affected assessments of the losses. First, Kahneman et al. (1993) found that people judged a series of environmental losses to be more "important" if caused by human action than if caused by a natural event. Second, DeKay and McClelland (1996) found that people placed higher priority on saving endangered species threatened by humans than on those threatened by natural forces.[2] Third, Brown et al.

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[1] What a lost resource is worth must be distinguished from how much compensation should be paid by the person who caused the loss. Compensation, if paid by the injurer, may include a penalty (especially if the action was avoidable) to be added to the cost of restoration. The penalty may both penalize the injurer and help to compensate the injured for the sense of violation they suffered (see Radin, 1993)

[2] Subjects were asked "How much should we be doing right now to save the species?" The higher priority of species threatened by humans may have been due in part to subjects assuming that human-caused endangerment was more amenable to intervention than was naturally caused endangerment.

(2002) found that the judged "seriousness" of several environmental losses was greater if they were caused by human action than if caused by a natural event.

This effect of cause on judgments of losses has also been found in assessments of personal injuries. Two sets of studies have documented this finding. First, Baron and Ritov (1993) and Baron (1993) asked subjects what they recommended regarding compensation to be paid to a person sustaining personal injury. Compensation was more often recommended when the injury was caused by another person or by a firm than when it was caused by nature. This was so even when subjects were told that the amount of compensation would have no effect on the amount of punishment, if any, that was imposed on the injurer.

The second set of evidence relates to jury awards. Most states in the U.S. use comparative negligence standards to determine the damage payments to injured parties. Juries are instructed to do two separate things; first they determine the responsibility of both the defendant and the plaintiff (the injured party), and then they estimate the total damage to the plaintiff, knowing that the court will reduce the ultimate award to the plaintiff below total damage if the jury found the plaintiff to be partly responsible for the injury. However, studies have found that juries' estimates of total damage are inversely related to the degree to which the plaintiff was considered responsible (e.g., Feigenson, Park, & Salovey, 1997; Zickafoose & Bornstein, 1999). Even though specifically instructed to determine the gross amount of damages incurred by the plaintiff without regard to the plaintiff's degree of negligence, jurors' estimates reflected in part their assessments of negligence.

The value of an environmental loss (to be compared for decision making with the cost of its restoration and future protection) is not the same as its "importance" or "seriousness." Value would typically be measured in monetary terms, such as willingness to pay to avoid the loss. However, willingness to pay appears to be related to judgments of importance or seriousness. For example, Hoehn and Randall (2002) found that judged "seriousness" of damages to water quality caused by mining was positively correlated with stated willingness to pay for restoration. Similarly, Kahneman et al. (1993) found that judged "importance" of environmental losses was positively correlated with stated willingness to pay for intervention. Thus, a better understanding of the relation of cause to judgments of importance, seriousness, and other indications of magnitude should be useful in interpreting judgments of willingness to pay. This study is a small step toward that enriched understanding. We look more closely at the effect of cause on judgments of seriousness.

With environmental losses, at least three kinds of human cause are possible. The previous research cited above did not differentiate among them. A loss may or may not be clearly attributable to a person or distinct group.[3] A cause not attributable to a specific person or entity is economic and population growth. For example, a decrease in air quality might be attributed to the increase in automobile use that occurs with growth. And if attributable to a specific entity, a loss might be the result of either an illegal action or carelessness.[4] For example, air pollution from emissions at an industrial plant may result from willful disregard of environmental laws or careless maintenance of pollution control equipment. We sought to determine how the judged seriousness of environmental losses varies among these three types of human cause—illegal behavior, carelessness, and growth—and how judged seriousness differs between those causes and natural causes. A natural cause of decreased air quality, for example, might be forest fires started by lightning.

Our basic approach was to obtain paired comparison judgments of seriousness of loss for a series of loss+cause descriptions, where some of the losses were presented separately with each of the four different kinds of cause. Subjects were asked to judge the losses, not the causes, though each loss description included a cause. Air quality was one of the losses we used, described as caused in each of the four ways mentioned above. Other losses were of elk in a national forest, of large trees in a nearby forest, and of aquatic life in a local river. We attempted to present the various loss+cause descriptions so as to maintain independence among the various paired comparisons. A subsidiary objective of the study was to assess the reliability of such judgments.

We hypothesized that judged seriousness would be greater for human-caused than naturally caused losses. Indeed, given the abundant evidence from previous studies, we would

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[3] Some evidence of the importance of attribution is found by comparing the study by Kahneman et al. (1993), mentioned above, with that by Walker et al. (1999). Most of the losses used by Kahneman et al., when described as human-caused, were not easily attributable to specific individuals with ample ability to pay for restoration. Kahneman et al. found for these losses that willingness to pay increased with judged importance. Walker et al. qualify the Kahneman et al. finding by showing that willingness to pay to restore human-caused losses depends on *who* caused the loss. People are willing to pay less when the entity causing the loss is clearly identifiable and considered able to pay, such as a corporation, than when the entity is society in general.

[4] A category of human cause of loss that we did not evaluate is intentional but legal loss, such as the loss of large trees resulting from a clear cut legally carried out by the land owner, or the loss of a view from growth of trees in a neighbor's yard (in the absence of covenants prohibiting such obstructions). Intentional but legal loss could also include loss by omission, that is, by not having done something that could have avoided the loss (Baron, 1993).

have been very surprised to find evidence to the contrary. Most importantly here, we also expected that losses due to illegal acts would be judged most serious of all, followed by losses due to carelessness and then losses due to economic and population growth.

## METHOD

### Participants and Experimental Design

Participants were 253 undergraduates at Colorado State University in Fort Collins, Colorado. Participation satisfied part of an Introductory Psychology course research requirement.

To examine the effect of cause on peoples' judgments of the seriousness of environmental losses, we obtained comparative judgments for 24 losses, each of which was attributed to a cause (the 24 loss+cause descriptions are called "items" herein). For example, one item was "Loss of 200 elk on National Forest land west of Fort Collins due to poaching (illegal hunting)," and another was "Loss of a ½ square mile of large ponderosa pine west of Fort Collins due to a new housing development." Criteria for selecting losses and causes included: (1) believability (the items should make sense to the subjects); (2) brevity (capable of being conveyed in a single sentence); (3) variety (the losses should involve a mix of different resources); and (4) comparability (the losses should not be so different in seriousness that judgments are overly obvious). Similarity of description format was maintained by beginning each item with "Loss of…" and transitioning to cause with "due to."

The 24 items consisted of 16 target items and 8 filler items. The 16 target items were created by crossing four losses with four types of cause. The four types of cause were illegal behavior, carelessness, economic and population growth, and natural event. The four target losses were such that they could actually be caused by each of the four types of cause. The 8 filler losses were different from each other and from the target losses. Type of cause was distributed evenly across the filler items such that each type of cause was represented twice.[5]

To minimize the chance of subjects using simplifying rules for making their choices, and thus to help maintain independence among the judgments, the items were grouped into four sets so that within a set subjects never compared a specific loss with itself (i.e., never compared two

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[5] Most of the losses are biological entities, such as eagles, elk, fish, and trees, but the following three are conditions affecting human health or enjoyment of the surroundings: loss of clean air days, loss of the view of the mountains, and loss of nighttime quiet.

causes of the same loss). This was accomplished by arranging the 16 target items into four groups of four items each. Each group of target items covered each of the four losses and each of the four causes (thus avoiding duplication of loss or type of cause within a group). The 8 filler items were combined with each group of four target items to form four sets of 12 items (Tables 1 and 2). Each subject responded to all possible pairs of the items in a set (6 pairs among the target items, 32 pairs comparing a target item with a filler item, and 28 pairs among filler items, for a total of 66 pairs per set). Each subject responded to all four sets. Thus, each subject responded to 4 x 66 = 264 pairs.

The filler items served two purposes: to cloak the focus on the target items, thereby helping to maintain independence among judgments of the target items, and to allow measures of reliability based on the repeated judgments of the filler item-by-filler item pairs that were judged four separate times by each subject. Reliability tests focused on two issues: whether responses to the filler items differed by set, and whether they differed by sequence of presentation (i.e., by whether they were encountered first, second, third, or last as the subjects proceeded through the four sets). Reliability tests were performed in terms of respondent consistency, item preference score, and time taken to make choices.

We adopted a Thurstonian (1927) model of the paired comparison response process, which characterizes judgment as a stochastic process through which the location of an item along the dimension of interest at a given time falls along a range distributed about the item's true value. For item $i$ the model is $U_i = V_i + \varepsilon_i$ where $U_i$ is a momentary relative magnitude along the judgmental continuum, $V_i$ is its expected value, and $\varepsilon_i$ represents dispersion attributed to random fluctuations in perception and judgment. Some degree of randomness is always expected, leading to inconsistency in a subject's paired comparisons. Inconsistency in choice increases the closer are the $V$s and the larger are the $\varepsilon$s of the items being compared. $V$, however, is assumed to remain constant for a person in a given judgmental context, such as in a session during which paired comparison responses are provided among a set of randomly ordered pairs of items. When used with a sufficient number of subjects, the paired comparison procedure, given certain assumptions about the $\varepsilon$s, allows the $V$s to be estimated for the population along an interval scale (Torgerson, 1958).

Table 1. Items.

**A. Target items (and target group number)**

Loss of 200 elk on national forest land west of Fort Collins due to

1. poaching (illegal hunting).
2. careless transmission of a disease from contaminated cattle.
3. deterioration of habitat caused by building new roads.
4. an unusually harsh winter.

Loss of a ½ square mile of large ponderosa pine west of Fort Collins due to

4. illegal logging.
1. incomplete extinguishing of a campfire.
2. a new housing development.
3. extremely rare high winds

Loss of all aquatic life in a 20-mile stretch of the Poudre River near Fort Collins due to

3. illegal dumping of industrial waste.
4. a petroleum spill from a careless driving truck accident.
1. runoff from a large construction site following heavy rain.
2. an extended dry spell.

Loss of 20% of the clean air days in Fort Collins due to

2. intentional violation of industrial emissions laws.
3. careless maintenance of industrial pollution equipment.
4. increasing automobile emissions from the growing city population.
1. lightning-caused forest fires in the West.

**B. Filler items**

1. Loss of 80% of all prairie dogs in Fort Collins due to illegal poisoning.
2. Loss of 60% of the bald eagles in northern Colorado due to illegal killing for their feathers.
3. Loss of all fish in City Park Lake due to an accidental herbicide spill.
4. Loss of a ¼-square mile of Douglas fir trees near the Poudre River to wildfire caused by a careless camper.
5. Loss of 25% of the view of the mountains from town due to housing development in the foothills.
6. Loss of nighttime quiet in your neighborhood due to a new freeway.
7. Loss of 10 large trees on the CSU oval due to old age.
8. Loss of 500 Canada geese in Fort Collins due to a natural bacterial infection.

Table 2. Experimental design

| Set | Items |
|---|---|
| 1 | Target group 1 (4 items) plus the 8 filler items |
| 2 | Target group 2 (4 items) plus the 8 filler items |
| 3 | Target group 3 (4 items) plus the 8 filler items |
| 4 | Target group 4 (4 items) plus the 8 filler items |

**Procedure**

The experiment took the average subject about 45 minutes to complete. Pretesting showed little or no drop in consistency as subjects proceeded through 264 comparisons. In any case, the repeated judgments of the filler items allowed us to test for a drop in consistency.

Subjects participated in the experiment in small groups but they did not interact, with each seated at a separate computer. Subjects were instructed to choose the "loss you consider to be the more serious" for each of the 264 pairs of items. The items of each pair were presented to subjects on the left and right sides of their computer screens. Subjects indicated their choices using the left and right cursor keys, and could undo their choice with the backspace key in order to make a correction.

Presentation order was randomized across subjects by, separately for each subject, randomly ordering the presentation of the four sets, randomly ordering the presentation of pairs within each set, and randomly ordering the position (left versus right side of the screen) of the two items of a pair. The four item sets were presented without a break between them, and subjects were not informed that the pairs were organized into four different sets.

The computer recorded the amount of time taken to enter each choice. These data show whether subjects become quicker in response time as they become more familiar with the items and the task, and allow an examination of the effect of presentation order on response time. Past study has shown that the time that most subjects require to make their choices drops rapidly over the first few choices and then settles down to a level of about 3 to 4 seconds per choice (Peterson & Brown, 1998). We expected this pattern to occur here as well, and in addition expected mean time to drop slightly across the item sets (from one set to the next, in the order of presentation). Of interest was whether this pattern would occur for each item set (i.e., whether the introduction of new items with the change to a new item set would initially cause decision times to lengthen).

**Data Analysis**

A subject's vector of the numbers of times each item was chosen above the others is the set of *preference scores*. Preference scores were computed for each set of 12 items, yielding four sets of preference scores per subject. If a subject's choices were perfectly consistent, the preference scores for a set would contain each integer from 0 to 11. Inconsistency in a subject's choices causes some integers to disappear and others to appear more than once.

Inconsistency among a subject's paired comparisons occurs as *circular triads*, which indicate intransitive choice. For example, the following circular triad could result from the three possible pairings of three items: A>B>C>A. An individual subject's *coefficient of consistency* relates the observed number of circular triads to the maximum possible number (David, 1988). If $t$ is the number of items in the set, the maximum possible number of circular triads, $m$, is $t(t^2-4)/24$ when $t$ is even as in this study. A maximum of 70 circular triads is possible for choices among all possible pairs of 12 items. Letting $a_i$ equal the preference score of item $i$ (i.e., the number of items in the choice set dominated by the $i^{\text{th}}$ item) and $b$ equal the average preference score (i.e., $(t-1)/2$), the number of circular triads for an individual subject, $c$, equals $t(t^2-1)/24 - 0.5\,\Sigma(a_i-b)^2$. The subject's coefficient of consistency is then $1-(c/m)$. The coefficient varies from 1.0, indicating that there are no circular triads in a person's choices, to 0, indicating the maximum possible number of circular triads. From prior study we expected coefficient of consistency to differ across subjects. However, we did not expect it to differ across item sets or orders of presentation.

The means (across subjects) of the preference scores for each item are considered to approximate an interval scale measure (Dunn-Rankin, 1983), and can be used as scale values of the items. We used this simple approach for measuring group preference, but for presentation we converted mean preference scores to mean estimated probabilities of choosing the items, in order to remove the dependence of preference score on the number of items in the set. This linear transformation was performed by dividing the mean preference score of each item by the number of pairs in which the item appeared (which is $t$-1 for a set of $t$ items if all possible pairs are judged). We estimated these choice probabilities separately for each set of items.

## RESULTS

### Reliability

***Test-retest reliability***. The 28 filler item-by-filler item pairs were judged four times by each subject, once for each set of target items. Aggregate preference scores for each filler item were computed for each set (Table 3), allowing a comparison across the sets. The six correlation coefficients comparing the four sets of filler item preference scores are all above 0.998, indicating that changing the target items from one set to the next had no effect on the relative seriousness of the filler items.

Table 3. Mean estimated choice probabilities of filler items

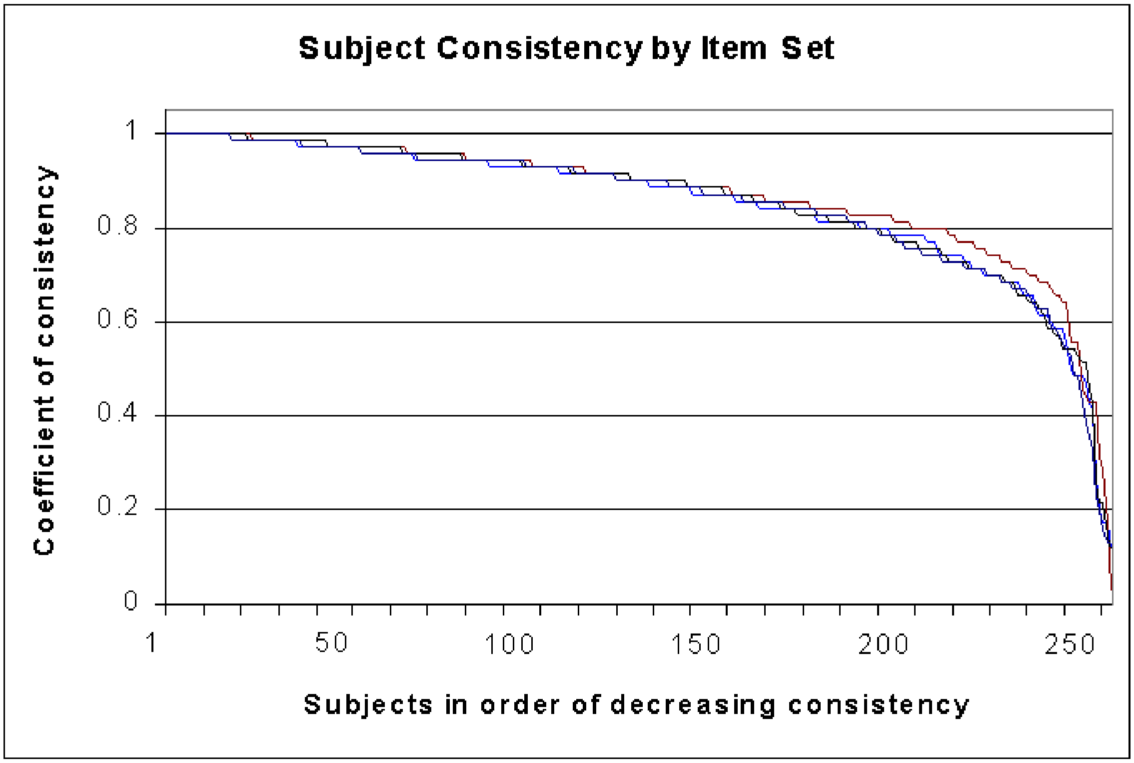
| Item[1] | Set 1 | Set 2 | Set 3 | Set 4 |
|---|---|---|---|---|
| 1 | 0.53 | 0.52 | 0.52 | 0.54 |
| 2 | 0.89 | 0.89 | 0.88 | 0.88 |
| 3 | 0.53 | 0.53 | 0.53 | 0.54 |
| 4 | 0.47 | 0.50 | 0.48 | 0.48 |
| 5 | 0.38 | 0.38 | 0.39 | 0.38 |
| 6 | 0.26 | 0.25 | 0.27 | 0.26 |
| 7 | 0.15 | 0.15 | 0.14 | 0.16 |
| 8 | 0.36 | 0.37 | 0.35 | 0.36 |

[1] Items are listed in Table 1.

A two-way (item-by-set) analysis of variance on individual subject preference scores of the filler items showed no significant difference among the four sets, $F(3, 8064) = 0.296$, $p = 0.828$, $\eta^2 < .01$, and no significant two-way interaction. In addition, an item-by-sequence two-way analysis of variance showed that sequence did not significantly affect judgments (i.e., that responses to the first set encountered did not differ from responses to the second set, etc.), $F(3, 8064) = 0.022$, $p = 0.996$, $\eta^2 < .01$.

***Consistency***. Mean coefficients of consistency across the 253 subjects were 0.85, 0.87, 0.86, and 0.85 for the first, second, third, and fourth sets, respectively, that subjects encountered. Minimum and maximum coefficients were not affected by sequence of presentation, ranging from 1.0 to about 0.1 regardless of whether the set was the first, second, third, or last to be encountered (Figure 1). Ninety percent of the subjects maintained a coefficient of at least 0.66 regardless of sequence of presentation. A minority of subjects was either extremely uncertain about their judgments or—more likely—simply made little attempt to answer meaningfully. A one-way analysis of variance of coefficient of consistency showed that sequence did not significantly affect consistency, $F(3, 1008) = 0.815$, $p = 0.486$, $\eta^2 < .01$.[6]

Figure 1.




Mean coefficients of consistency for the four sets (regardless of the order in which the sets appeared) ranged from 0.84 to 0.87. An analysis of variance showed no significant difference among the four sets, $F(3, 1008) = 1.692$, $p = 0.167$, $\eta^2 < .01$.

***Decision Time***. Another indication of reliability is found in the time subjects took to make their choices. As would be expected, the time required for making a choice decreased as subjects proceeded through the choices of a set (Figure 2), presumably because they gradually became more familiar with the items of the set. For example, with the first set of items subjects encountered they took an average of 16.3 seconds to respond to the first pair, an average of 9.4 seconds for the second pair, 8.3 seconds for the third pair, etc., with mean time dropping below 4 seconds by about the 40th pair. Although there was no break between the last pair of the first set

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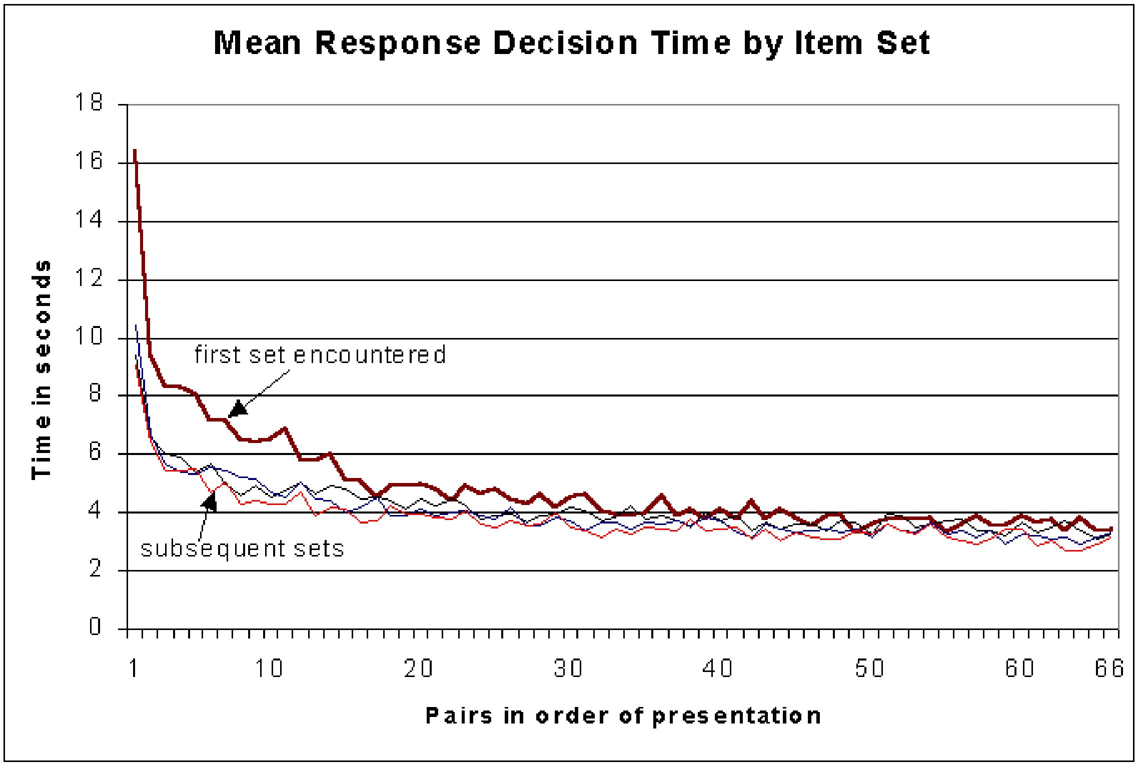
[6] Coefficient of consistency is not normally distributed (Figure 1), suggesting that a nonparametric test may be more appropriate. A Kruskal-Wallis test shows no significant effect of sequence on coefficient of

and the first pair of the second set, the latter took about 10 seconds to complete (Figure 2), presumably because of the new target items introduced upon the switch between sets. Time then dropped as before, falling below 4 seconds by about the 25th pair. A similar pattern is observed for the third and forth sets encountered.

Figure 2.




Mean decision times were 4.9, 4.2, 4.0, and 3.8 seconds for the sets in the order in which they were encountered. A one-way analysis of variance of time showed a significant difference among the four orders, $F(3, 260) = 8.493$, $p < 0.001$, $\eta^2 = .09$. A Scheffé test showed that mean decision time of the first set encountered was significantly different from that of each of the other 3 sets encountered, but that mean times among the latter three sets encountered were not significantly different from each other.

**Cause of Loss**

Figure 3 shows the effect of cause of loss on the judged seriousness of the four target losses. All four of the losses were judged as more serious if caused by a human action than if

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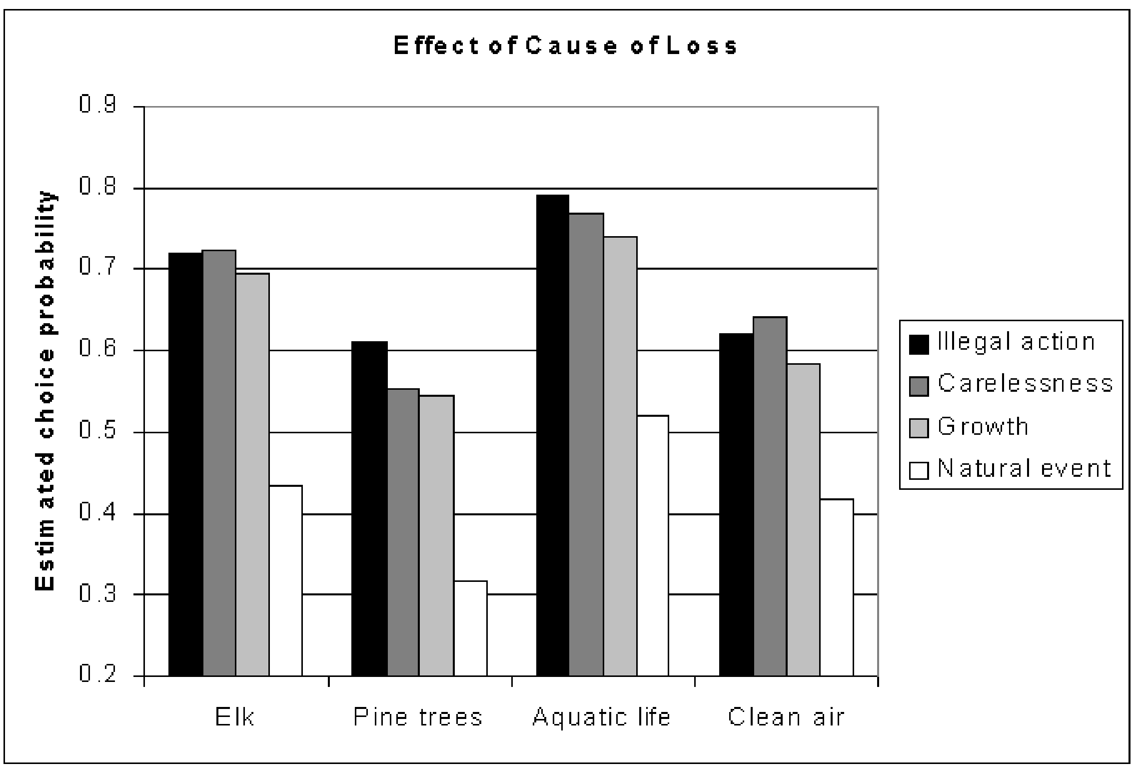
consistency, $\chi^2 = 2.19$, df = 3, p = 0.533.

caused by a natural event. There was little difference, however, among the three types of human-caused loss, although growth resulted in a slightly lower judgment of seriousness than did illegal action or carelessness. A two-way (cause-by-loss) analysis of variance including main effects and two-way interactions of the preference scores from the individual subjects found significant differences among types of cause, $F(3, 4032) = 362$, $p < 0.001$, $\eta^2 = .21$, as well as a significant cause-by-loss interaction, $F(9, 4032) = 3.02$, $p = 0.001$, $\eta^2 < .01$. (Significant differences were also found between losses, as reported in the next section.) A Scheffé test found that the seriousness of losses caused by illegal behavior was not significantly different from the seriousness of losses caused by carelessness ($p = 0.476$) but that the seriousness of losses caused by growth was significantly lower than that caused by illegal behavior ($p < 0.001$) or carelessness ($p = 0.011$), and that the seriousness of losses caused by natural events was significantly lower than that caused by any of the human causes ($p < 0.001$ for each of the three human-caused losses). Additional tests are reported in the Appendix.

Figure 3.



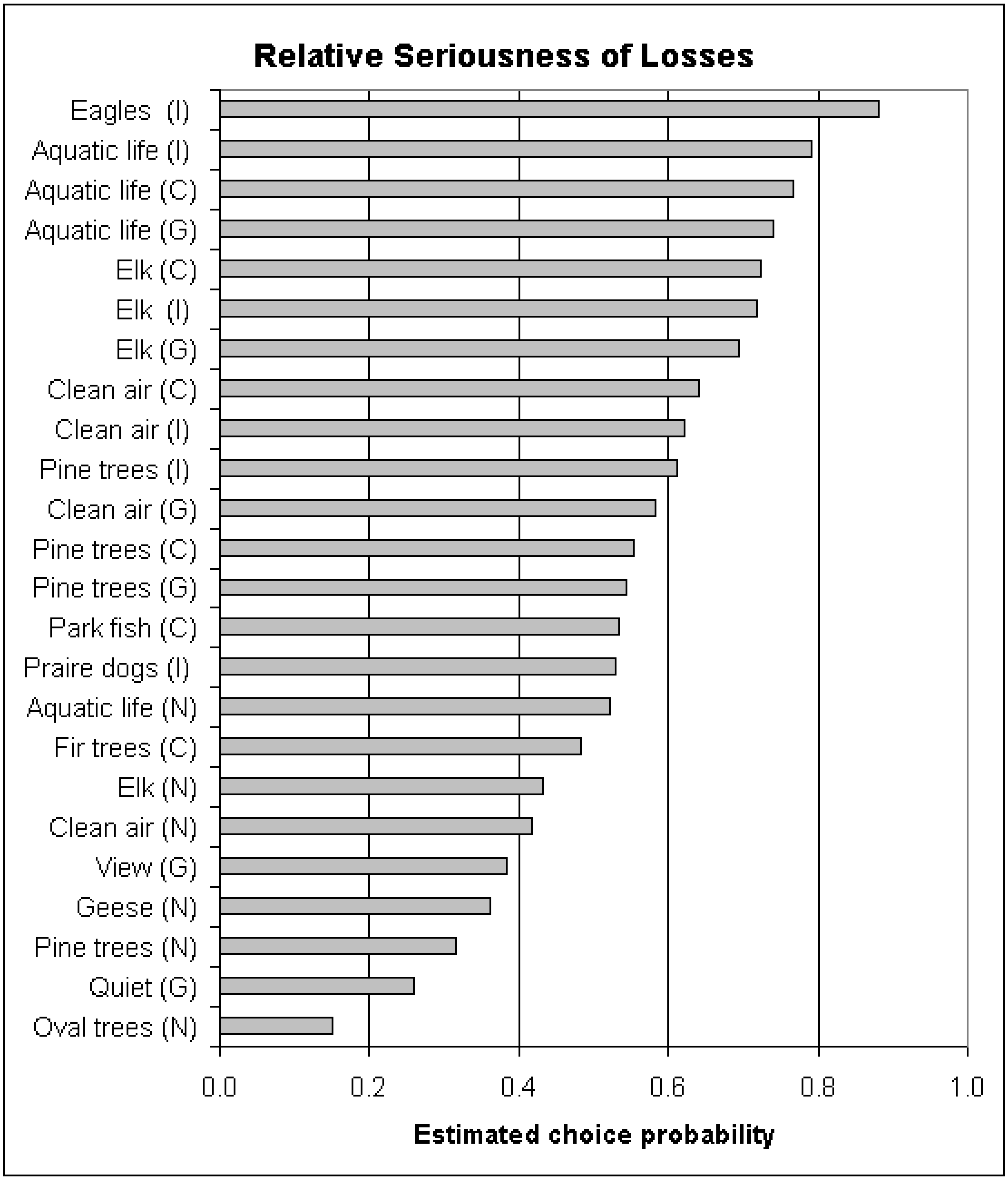

The significant cause-by-loss interaction can be explored by analyzing the causes two at a time. Two-way analyses of variance showed that the cause-by-loss interaction was significant (at $p < 0.05$) for three pairs of causes: 1 and 2, 1 and 4, and 3 and 4. The interaction for causes 1 and 2 (illegal action and carelessness) is most evident in Figure 3 because order reverses: loss of clean air was judged as more seriousness if caused by carelessness than by illegal action, whereas for two of the other losses the reverse is true. The interaction is likely to be due to the details of the descriptions of cause. For example, perhaps the use of "pollution" to describe the loss of clean air due to carelessness caused the loss to be more salient than did the use of "emissions" to describe that loss when due to illegal behavior. If we are correct about the cause of the interactions, they are of relatively little interest here, except to highlight the importance of wording in describing the causes of losses.

**Relative Seriousness**

Figure 4 shows the estimated choice probabilities of the 24 loss+cause items. Illegal killing of eagles was considered the most serious loss. Losses of aquatic life by each of the three types of human action were next most serious, followed by losses of 200 elk by the three types of human action. The six next most serious losses were those of clean air and ½ square mile of pine trees by each of the three types of human cause. Accidental loss of the fish in City Park Lake (a small stocked lake) was next, followed by illegal poisoning of prairie dogs. The last nine losses included six naturally caused losses, partial loss of a view and loss of nighttime quiet both due to growth, and loss of ¼ square mile of fir trees due to carelessness.

A two-way (item-by-set) analysis of variance on individual subject preference scores for the filler items showed that item was highly significant, $F(7, 8064) = 1052$, $p < 0.001$, $\eta^2 = .48$, but that the item-by-set interaction was not significant, $F(21, 8064) = 0.304$, $p = 0.999$, $\eta^2 < .01$. A Scheffé test showed that each filler item was significantly different from each other filler item ($p < 0.003$) except for item 1 versus item 3 ($p = 1.0$) and item 5 versus item 8 ($p = 0.660$). And a two-way (cause-by-loss) analysis of variance on individual subject preference scores for the target items (mentioned in the previous section) showed that loss was highly significant, $F(3, 4032) = 181$, $p < 0.001$, $\eta^2 = .12$. A Scheffé test showed that each target loss was significantly different from each other target loss ($p < 0.001$). Thus, there was sufficient agreement among subjects to yield clear distinctions among the losses. Additional tests are reported in the Appendix.

Figure 4.




I = illegal, C = carelessness, G = growth, N = natural

## DISCUSSION

The paired comparison method yielded very reliable results. We found that although subjects differed in the consistency with which they judged the seriousness of the losses (coefficients of consistency ranged across subjects from 1.00 to 0.10), relatively few subjects fell in the lower half of the coefficient range. A small minority of subjects were either extremely inconsistent in their judgments or simply did not take the exercise seriously. More importantly, we found that consistency did not vary across the four sets or by the sequence of presentation, increasing our confidence that most subjects were able to meaningfully respond to all 264 pairs of items.

The effect of cause of loss on judged seriousness was very strong. Environmental losses were considered much more serious when they were caused by human actions than when caused by natural events. Clearly, judged seriousness of an environmental loss is a function of the cause of loss as well as the nature and magnitude of the loss. This finding is similar to that of prior studies (mentioned in the Introduction) that focused on "importance" of environmental losses or on how much society should be doing to save endangered species, and to studies that focused on compensation for personal injuries. Thus, the finding appears to be robust to considerable changes in the type of loss and the evaluation criterion.

Distinctions among the three types of human cause—illegal behavior, carelessness, and the effects of growth—were relatively minor, although losses were slightly less serious when caused by growth than when caused by illegal or careless behavior. In other words, the distinction between human and natural cause was much more important than the distinction between clearly attributable and non-attributable human cause.

Kahneman et al. (1993) ascribe the greater importance of human-caused, as opposed to naturally caused, losses to a sense of outrage. This feeling of outrage is linked to the sense of violation that accompanies human-caused losses of environmental assets. When someone harms an environment we hold dear, they have taken something from us without our permission. It is this sense of violation that probably underlies the damage compensation codified in such laws as the Clean Water Act or the Oil Pollution Prevention Act, which Baker (1995) has argued is akin to the pain and suffering awards of torts. However, outrage is only one of the reactions that are likely to describe that sense of violation. Outrage probably applies best to illegal acts, and perhaps also applies well to negligence. It applies less well to the general effects of economic and population growth, to which we all to some extent contribute. The sense of violation associated with loss caused by growth may be due more to concern, or even in some cases guilt, about our own actions or at least about the general process of human activity and consumption.[7] Just as feelings of moral responsibility can enhance willingness to pay (Walker et al., 1999), they may also affect judgments of seriousness of loss if the judges are themselves partly responsible for the loss.

When environmental losses are caused by natural events, the sense of violation or concern that is provoked, or the sense of responsibility for the loss that we may feel, is probably less than when the loss results from human actions. In addition, we suggest that naturally caused losses are judged to be less serious because they are considered unavoidable and in the natural scheme of things, as opposed to human-caused losses which are avoidable. Indeed, some naturally caused losses may even be considered beneficial in the long run. For example, wildfire reduces accumulated fuels, returns nutrients to the soil, and can improve wildlife habitat. In contrast, human-caused losses, no matter what the type of human cause, may be considered unnatural impositions on the ecological order. It is perhaps partly because of this fact that the law provides no compensation for the loss of natural entities caused by natural events. The sense of violation at the loss of large trees in a nearby forest that one feels if they were lost to illegal logging is largely absent if the trees were lost to naturally occurring high winds.[8]

It should be mentioned that the ranking of losses established in this study, which is based on the judgments of university students, may not transfer to other populations. The preferences of students may reflect, among other things, their stage in life. For example, students may be less sensitive to losses of nighttime quiet (one of the filler losses) than middle-aged adults.

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[7] A sense of violation may also help to explain the results of studies of compensation for personal injury. If subjects desire to compensate victims for the violation they have suffered as well as for the physical loss, more compensation would be due following a human-caused loss than following a naturally caused loss.

[8] In our study, there was no mention of punishment of the injurer. Because the possibility of punishment was unspecified, subjects were left to make whatever assumptions they chose. Such assumptions could have enhanced the judgments of seriousness of human-caused, as opposed to naturally caused, environmental losses. We do, however, have a suggestion, in the work of Baron, that the possibility of punishment of the injurer is not essential to a distinction between judgments of naturally caused and human-caused losses. As mentioned in the Introduction, Baron (1993) controlled for the possibility of punishment in his study of personal injury losses by instructing subjects that compensation would have no effect on the injurer, yet he still found that some subjects' assessments of compensation for injured parties were higher for human-caused injuries than for naturally caused injuries.

Nevertheless, we expect that the broad conclusions of this study, especially the relative seriousness of the four types of cause, will transfer well to adults in general.

Regardless of why naturally caused losses are judged less serious than otherwise identical human-caused losses, it is clear that they *are* so judged. Perhaps the safest approach to establishing a public preference-based ranking of the seriousness of environmental losses (see Brown et al., 2002) would be to not list the cause of losses when they are presented for judgment. However, results of studies of juries' estimates of damage (cited in the Introduction) suggest that subjects would find it difficult to judge the seriousness of environmental losses irrespective of cause. Listing losses without an associated cause runs the risk that respondents will assume causes, and more likely assume certain causes for certain losses, thereby failing to avoid the problem.

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## APPENDIX

The experimental procedure followed for this study required many responses per subject. Multiple responses from the same subject cannot be assumed to be independent (i.e., they may be correlated). The analysis of variance procedures reported in the text assume independence. Correlation among multiple responses per subject may be controlled for using the Mixed procedure in SAS to test for treatment differences. This appendix reports results of statistical tests using this procedure for the principal tests of this study, namely those comparing causes and losses.

The cause-by-loss analysis using the Mixed procedure found cause to be highly significant, $F(3, 756) = 326.60$, $p < 0.001$, loss to be highly significant, $F(3, 756) = 83.83$, $p < 0.001$, and the cause-by-loss interaction to be highly significant, $F(9, 2268) = 7.37$, $p < 0.001$. Because of a significant cause-by-loss interaction, comparing causes is safest if done separately for each loss (Table A1).

Table A1. Significance of differences between causes (SAS Mixed procedure, Tukey-Kramer multiple comparisons test, probability level with a Bonferroni adjustment to the alpha level to account for performing numerous separate tests)

| Cause[1] | Target loss | | | |
|---|---|---|---|---|
| | Elk | Pine | Aquatic life | Clean air |
| 1 vs 2 | 0.994 | <0.001 | 0.382 | 0.509 |
| 1 vs 3 | 0.268 | <0.001 | 0.003 | 0.048 |
| 1 vs 4 | <0.001 | <0.001 | <0.001 | <0.001 |
| 2 vs 3 | 0.163 | 0.918 | 0.232 | <0.001 |
| 2 vs 4 | <0.001 | <0.001 | <0.001 | <0.001 |
| 3 vs 4 | <0.001 | <0.001 | <0.001 | <0.001 |

[1] 1 = illegal behavior; 2 = carelessness; 3 = economic and population growth; 4 = natural event

From Table A1 we see that naturally caused losses were always considered less serious than any of the human-caused losses. Among the human causes, losses due to illegal behavior were considered more serious than losses due to growth for three of the four losses, and more serious than losses due to carelessness for only one of the losses; losses due to carelessness were considered more serious than losses due to growth for only one of the losses. Thus, in comparison with the Scheffé tests reported in the text, results are the same except that the differences between growth and illegal behavior and between growth and carelessness are not consistently significant as was suggested by the Scheffé test.

Because of a significant cause-by-loss interaction, comparing losses is safest if done separately for each cause (Table A2).

Table A2. Significance of differences between losses (SAS Mixed procedure, Tukey-Kramer multiple comparisons test, probability level with a Bonferroni adjustment to the alpha level to account for performing numerous separate tests)

| Target loss[1] | Cause | | | |
|---|---|---|---|---|
| | Illegal behavior | Careless-ness | Growth | Natural event |
| 1 vs 2 | <0.001 | <0.001 | <0.001 | <0.001 |
| 1 vs 3 | <0.001 | 0.044 | 0.045 | <0.001 |
| 1 vs 4 | <0.001 | <0.001 | <0.001 | 0.848 |
| 2 vs 3 | <0.001 | <0.001 | <0.001 | <0.001 |
| 2 vs 4 | 0.943 | <0.001 | 0.112 | <0.001 |
| 3 vs 4 | <0.001 | <0.001 | <0.001 | <0.001 |

[1] 1 = elk; 2 = ponderosa pine; 3 = aquatic life; 4 = clear air

From Table A2 we see that loss of all aquatic life in a 20-mile stretch of the Poudre River near Fort Collins was always considered more serious than loss of ½ square mile of large ponderosa pine west of Fort Collins or loss of 20% of the clean air days in Fort Collins, and that loss of 200 elk on national forest land west of Fort Collins was always considered more serious than loss of the large ponderosa pine. For other comparisons, the significance of the difference between losses varies with the cause.