What is the Value of a Bird? A Proposed Methodology Based on Restoration Costs and Scarcity by Species

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Abstract: This paper begins by examining the recent history of natural resource damage assessment (NRDA), focusing on the shortcomings of recent methodologies and the need to develop simplified and reasonable methods for estimating the value of individual birds. A theoretical model is proposed, where the value of a bird is a function of known restoration costs for certain species, the relative scarcity of each species, the current population trend of the species, and other factors. Finally, an preliminary (and incomplete) example is presented, using the model to estimate restoration costs per bird for regularly occurring species in California.

Background of NRDA and Bird Kills

In the aftermath of an oil spill or other pollution event, various federal and state statutes, such as the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA or Superfund), the Oil Pollution Act of 1990 (OPA), and California=s Lempert-Keene-Seastrand Oil Spill Prevention and Response Act (Government Code " 8670 et seq.), authorize trustee agencies to seek monetary compensation for injured natural resources. The Department of the Interior, responsible for promulgating NRDA regulations pursuant to CERCLA, has suggested that Acompensable value@ due to the public should Aencompass all of the public economic values associated with an injured resource, including use values and passive-use values such as option, existence, and bequest values@ (56 Federal Register 19760 (1991)). California Fish and Game Code ' 2014 specifies that Athe state may recover damages in a civil action against any person or local agency which unlawfully or negligently takes or destroys any bird, mammal, fish, reptile, or amphibian...@ and that Athe measure of damages is the amount which will compensate for all the detriment...@

Since the Exxon Valdez oil spill in 1989, NRDA has evolved into a well-defined discipline, with its own case history, legal precedents, and economic literature. While debates over contingent valuation were waged in many quarters, the National Oceanic and Atmospheric Administration (NOAA), responsible for promulgating NRDA regulations pursuant to OPA, released federal guidelines in 1996, recommending that the measure of damages be based on restoration costs. That is, the public may be compensated for the interim lost use of the resources based on the cost to supply (or re-create) the amount of natural resource services that were lost due to a pollution event. This Acompensatory restoration@ is not to be confused with Aprimary restoration@, which are post-cleanup actions at the site of the incident designed to speed the recovery of the impacted resources. NOAA recommends Habitat Equivalency Analysis (HEA) as a preferred method for calculating damages (see Mazotta et al. 1994, Unsworth and Bishop 1994, and NOAA 1995 for details on this method).

This recommendation quickly shifted the basis for valuing natural resources from the demand side to the supply side. The question was no longer Ahow much does the public value this resource?@ but Awhat does it cost to create, enhance, or restore this resource?@ It seemed as if economists using such valuation methods as contingent valuation and travel cost analysis presumably could be replaced by restoration ecologists and accountants using the annuity formula, at least in cases that did not involve active human uses.

Aside from the philosophical questions raised by this methodological shift, a host of practical questions have arisen. HEA is well-suited for injuries to habitats for which there are known restoration alternatives and well-documented costs. However, there are many pollution events that have negligible impacts to habitat but kill a large number of animals. The most common example of this is an oil spill into open water where the oil moves into the water column and atmosphere, and/or is cleaned up. Thus, it impacts no shoreline habitat but often kills many birds that contacted the oil while it was on the water=s surface.

Those conducting the NRDA of the North Cape oil spill faced this problem, but were largely limited to two species of birds (loons and eiders). They successfully adapted HEA into a bird resource equivalency analysis (REA) and calculated the number of lost loon and eider years due to the spill (Sperduto et al. 1999). They further benefitted from the existence of restoration data, so that they could estimate the potential gain (in Abird years@) from a proposed restoration project. The projects could then be scaled to provide the appropriate amount of compensation.

However, in many spills a wide variety of species of birds are impacted, such that often no one species accounts for even the majority of the birds killed. In this situation, replicating the North Cape bird REA for each and every impacted species would be both time consuming and expensive, and undoubtedly limited by a lack of data regarding potential restoration benefits. The dilemma is the fact that we have restoration project data (regarding both the benefits and costs) for only a handful of the 650 or more bird species that regularly occur in the United States. It is thus impractical to develop a REA for all of these species. Additionally, responsible parties desire to minimize assessment costs and avoid lengthy and expensive studies.

The Type A model, developed to model the impacts of oil spills and to calculate the damages, anticipated this situation, where values per bird would be required. In cases where habitat restoration fails to address impacts to certain species, the Type A model flips from a supply-based valuation method to a demand-based method, relying on a Aprice list@ for birds by species. These values were estimated based on the likelihood of viewing a species from shore, and vary from region to region. However, the resulting list of values per species is at best unsatisfying. In many cases, the results are baffling to both the restoration ecologist and the avid bird watcher. A Tundra Swan, rather common inland in appropriate habitats, is listed at over $13,000 per bird year in one region, while the Common Murre, a seabird struggling to recover from decades of human-induced population impacts, is valued at just over $1 per bird year.

A Proposed Model

This paper focuses on this problem, addressing the practical question of how to estimate restoration costs for all species of birds. The basic idea is to identify well-documented restoration benefits and costs for a few species and to extrapolate those values to all species based on the relative scarcity of the species and other factors.

An underlying question is the correlation between the value of a bird, as measured by public demand, and the costs to Asupply@ a bird, as measured by restoration costs. Certainly the NOAA recommendations presume this correlation. The key premise to this model is that public value and restoration costs are correlated with each other, and that both are negatively correlated with the population status of the species. That is, with some caveats, scarce birds are more valued by the public and are more expensive to restore, and common species are less valued and are cheaper to restore.

With respect to the supply side, is it truly cheaper to restore common birds, and more expensive to restore rare birds? What little data there is does suggest this correlation, as will be presented in the forthcoming example. Rare species typically have narrow and specific habitat preferences, often in conflict with human activities. The Spotted Owl=s affinity for old growth coniferous forests is an obvious example. With this species, a typical restoration alternative is the acquisition of land. The opportunity cost of preserving such habitat, which also has a high commercial value, is thus quite high. At the other end of the spectrum, common species are often adapted to a wide variety of habitats, including those with considerable human disturbance. Anyone seeking to restore one of these species may have a wide variety of potential restoration options, some of which may be relatively inexpensive (and involve little opportunity cost). However, there will certainly be individual species, based on their ecological preferences, that do not fit this overall pattern.

Note that bird restoration projects may be quite variable in their design and goals. They may seek to increase fledgling success rates or even simply expand the number of nesting birds.

Such goals may be achieved via efforts to reduce human disturbance or animal predation of nests, or by somehow improving the nesting habitat by altering the vegetation or landscape in some way. Other projects may seek to increase juvenile or adult survival rates on the breeding or wintering grounds by implementing measures to minimize whatever is killing the birds. These are only some examples.

With respect to the demand side, we can examine the behavior of active bird viewers (also known as Abird watchers@ or Abirders@). Such people may vary in their willingness to pay to view birds. We can think of the casual backyard birder with a bird feeder, the occasional birder who visits a wildlife refuge or attends a birding festival a few times a year, or the hardcore birder who flies across the country on a moment=s notice to view a rarity. The ends of the spectrum illustrate the basic principle: that the value of a bird is a function of the frequency of it being seen. Small expenditures are paid to see common birds; large expenditures for rare species. However, using scarcity as the basis for the value of a bird ignores other attributes that may also contribute to a bird=s value. Larger and/or more colorful species have more charisma, and may have greater value for some people. Game birds (e.g., ducks, geese, pheasants) have a consumptive value, as well as non-consumptive value. Alternatively, a few species (e.g., crows, gulls) may be viewed negatively by some.

Even if we accept the notion that scarce resources are more valuable, when it comes to natural resource management, scarcity may not communicate the entire status of the population. Some bird species (e.g., Heermann=s Gull, Elegant Tern, and Brown Pelican) are rather common, yet highly vulnerable because they nest at only a few locations. Perhaps a Avulnerability index@ that incorporates scarcity as well as other parameters (such as number of breeding colonies and population trends) would provide a more complete measure of population status.

One additional problem is the definition of scarcity. A bird may be scarce in one region, yet quite common elsewhere. Thus, the geographic area of reference becomes relevant. For example, an oil spill off California may kill a Long-tailed Duck (formerly known as Oldsquaw), which is rather rare there but much more common in other parts of North America. Since species are listed as threatened or endangered, as well as managed by trustee agencies, at a more regional or statewide level (in order to protect regional sub-populations), I would suggest a state or regional level as the maximum geographic unit when defining scarcity, but with care exercised in applying the results to species like the Long-tailed Duck in California. At the other end of the spectrum, there is often bird abundance data at the county level as well, which may be used in defining scarcity. This geographic unit may be so small, however, that a pollution event may transcend its boundaries. Certainly, the non-consumptive users (bird watchers) that contribute to the bird=s value can travel from outside a county to watch wildlife and do so quite regularly. Additionally, a restoration project seeking to benefit birds may not be entirely within the county where the pollution event occurred.

All these caveats aside, we will forge ahead, using the premise that value, and thus restoration costs, are correlated with scarcity. More formally, we propose that restoration costs (C) are a function of the overall size of the population (Q). Thus, we have

$$C(Q) \text{ where } dC/dQ < 0.$$

Further more, let us hypothesize a relationship between cost and population size, whereby costs increase exponentially as a species is more scarce ($d^2C/dQ^2 > 0$). Figure 1 illustrates this simple principle and the resulting curve is somewhat intuitive. The most common birds are relatively inexpensive to restore, while the rare species may involve exponentially increasing expenses. One can think of the millions of dollars spent to help the California Condor recover from the brink of extinction.

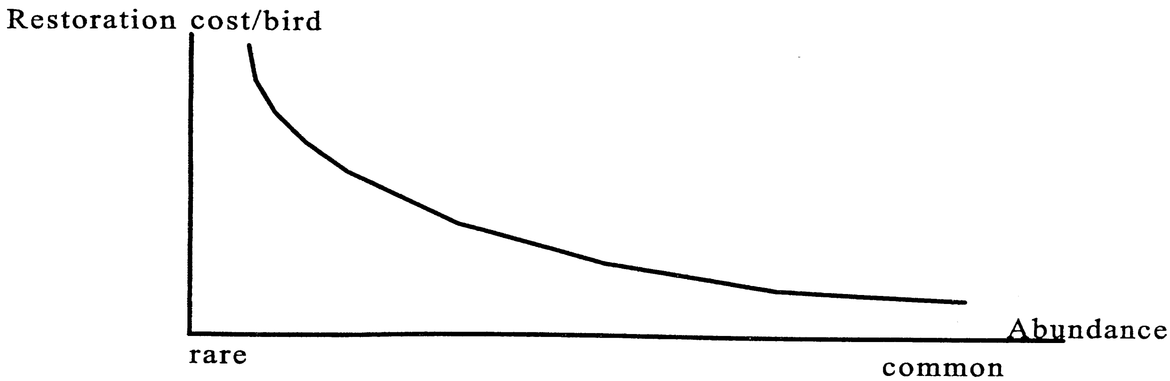

Figure 1: Restoration Costs for Each Species

Note that the costs per bird from these restoration projects are not simply based on the cost of the project divided by the potential number of new birds or new bird years created. Rather, they are derived from REAs of the lost bird years due to a bird kill and the bird years gained from the restoration project. The cost of the REA-scaled project is then divided by the original bird kill, giving us the true cost per bird killed in the incident.

This approach will create a discrepancy between species with steady (or increasing) populations and those with declining populations. REA calculates lost bird years, factoring in the natural recovery time of the species and thus calculating the interim loss. For a species whose population is steady (and assuming the incident does not cause a catastrophic population-level impact), we might assume that only one or two generations are lost, or even that only one year=s worth of birds are lost (see Sperduto et al. 1999). (How many generations and/or years to carry out injury in a REA is a subject of another paper in progress.) Beyond one or two generations, we assume the population will naturally recover from the incident and no additional losses are incurred. For a species with a declining population, lost birds will never be replenished naturally and are therefore lost into perpetuity. In this case, the number of lost bird years per individual killed is disproportionately higher than for other species. In fact, some preliminary REA results for certain species suggest the number of lost bird years per individual killed may be five to ten times greater. Thus, our model, as it stands now, estimates the REA-based restoration costs of a group of birds treated in a uniform manner with respect to the length of impact (e.g., one generation vs. into perpetuity).

If we simply divide all species into those that would suffer a one generation impact and those that are lost into perpetuity, an appropriate and simple addition to our model would be a dummy variable (D) for species with declining populations. For these species, the REA assumes a bird is lost into perpetuity. The equation now becomes

$$C(Q,D)$$

where $dC/dD > 0$. That is, REA-based restoration costs per injured bird increase if the species is declining.

Formally, let us take the most simple route (mathematically) and assume that the elasticity (b) of cost with respect to abundance is constant. For every percentage change in the abundance of a species, there is a fixed percentage increase in its restoration costs. We can employ a simple demand-style function, where:

$$Q = a \cdot C^b$$

where a is a constant and b is the elasticity between cost and population size. D, the dummy variable for declining species, simply shifts our curve up on Figure 1. In order to estimate C for each species, all that is required is Q for each species and enough data points of C to enable us to estimate the values of a and b.

Note that the proposed functional form will produce a substantial confidence interval for the rarer species, simply because the curve is shallow for the common birds but quite steep for the rarer species. Thus, for the rare species the predicted restoration costs will be quite sensitive to the parameters a and b. For example, if the curve was fit so that a very common bird has a restoration cost of $120/bird and we assume an elasticity (b) of -1.0, a = 114. If we assume that b = -0.5, a = 10.4. In the first case, a moderately common bird may have a restoration cost somewhere between $200 and $300 per bird, depending on which of the two sets of parameters we choose. However, for a rare bird, the estimated restoration costs will range from $500 to $2,500 per bird. This problem may be irrelevant, however, as case-specific REAs are likely to be developed for any NRDA involving rare species. It is primarily for the more common species that we need a tool for estimating restoration costs.

Preliminary Results from California

We have begun applying the proposed model to California. The first step was to acquire a measure of the abundance of each of the regularly occurring species in the state. For the purposes of this exercise, we have developed an Aabundance index@ using DeSante and Pyle (1986) and county bird checklists. The details of this index, as well as suggestions for improvements, are explained in Appendix A (not available in this Working Draft; contact the author for details). For each species, we have created an abundance index (Q in our model), ranging from 0 to 1, from rare to common respectively.

The second step is to identify REA-based restoration costs per bird for as many species as possible. Ideally, the data will include a mix of common and rare species. Care must be taken as many restoration projects target entire habitats or areas, not just a single species. Nevertheless, there are well documented projects in California for Mallard nesting habitat and for Common Murre nesting habitat. Estimating the REA-based costs for California Condor restoration would be an endeavor unto itself, but suffice it to say the number is possibly several hundred thousand dollars per bird. Simply looking at these three examples lends support to our hypothesized exponential function, as depicted in the curve in Figure 1.

Table 1: Species with Known Restoration Costs (based on REA Calculations)

SPECIES	ABUNDANCE INDEX	RESTORATION COST/LOST BIRD
Mallard	.9500	$120
Common Murre	.2948	$600
California Condor	.0001	$?00,000

[Note: research into restoration costs for other species is currently on-going.]

Note that this exercise may be extended to rarely occurring species in the state, such as vagrants from the eastern U.S. or from Asia. The results, however, are largely erroneous, as suggested in the previous discussion of scarcity with respect to geographic unit. The abundance index values for these species are so low that the corresponding estimated costs per bird are in the millions of dollars. The true costs of restoring these species, especially in the regions where they normally occur, is undoubtedly much lower. Thus, lines must be drawn, not just around the geographic unit but around the appropriate species to consider in the analysis.

Another preliminary finding is that Western Bluebirds are unexpectedly cheap to restore. With an abundance index of .7000 in California, a curve fit to the Mallard and Common Murre above would estimate bluebird restoration costs at approximately $180 per bird. However, a specific REA-based analysis of a restoration project for bluebirds (involving the creation and monitoring of bluebird nest boxes over a 12-year period) estimated the costs at $30 per injured bird. It may be that songbirds and similar species are cheaper to restore than larger birds such as waterfowl, seabirds, and raptors, who generally nest in wetlands or other sensitive habitats. These larger birds are generally K-adapted species with slow reproductive capacity and high annual survival rates (except waterfowl), whereas songbirds are closer to r-adapted species that produce many juveniles per year but have low annual survival rates. Further research will explore this issue.

Conclusions

As methods for NRDA increasingly use restoration costs, rather than consumer valuation, as their basis, knowledge of potential restoration costs are at a premium. However, scarce data and a lack of restoration history for many species limit the applicability of species-specific REAs to scale compensatory restoration projects. This proposed method attempts to utilize the limited data that exists regarding bird restoration and to extrapolate that to other species. The goal is thus to estimate the potential restoration costs of these species, or at least to approximate the supply-side driven value that may be associated with them. Given the inherent variability in wildlife restoration, more data is needed to complete the application of this model to California birds, but preliminary information suggests it may be worthwhile.

This model may then be used in expedited NRDAs to minimize assessment costs and estimate restoration costs, especially in cases where a wide variety of species have been impacted.

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