

Resource Equivalency Analysis (REA) Technical Note: Scaling Directly Proportional Avoided Loss Mitigation/Restoration Projects

Issue

A resource equivalency analysis (REA) responds to the question, “What, but for the event, would have happened to the injured species?” With REA, the services of the birds killed are quantified in physical units of *bird-years*.¹ The selected compensation is *scaled* so that the quantity of replacement bird-years (credit) equals the quantity of lost bird-years (debit) in present value (PV) terms to fully compensate the public for depletion of that individual or groups of individuals from the public trust, i.e., no net loss of birds. In the case of an avoided loss project where the estimated prevented loss of bird-years (mitigation, restoration) is *directly proportional* to the loss of bird-years (e.g., from “take,” chemical releases, oil spills), the life history inputs (e.g., longevity, age distribution, survival rates, reproduction) do not affect the final results of the credit owed.

Example

In the REA framework to mitigate the take of eagles from wind power operations, the level of take (number of eagles annually), the avoided loss of eagles per compensatory mitigation action (e.g., mitigated electric pole) and the timing of the mitigation relative to the take have a direct effect on the credit owed. The other life history inputs, including survival rates and reproduction, do not affect the final results, as described below.

For the purposes of the Eagle Conservation Plan Guidance (ECPG), the Service developed an REA example to calculate compensatory mitigation for the loss of golden eagles caused by wind power. The Service developed the following scenario:

Example 1: An annual take of one golden eagle over a five year permit renewal period, starting in 2012. Projected compensatory mitigation involves retrofitting of high-risk power poles. The utility pole retrofit would occur in calendar year 2012, thus avoiding the potential loss of golden eagles from electrocution. Proper operation and maintenance (O&M) of all retrofitted poles is an assumption; hereafter required for 10 years. The results of the model are expressed in the total number of electric power poles to be retrofitted to equate to no net loss of 5 golden eagles (1 eagle annually over five years). The cost to retrofit the power poles may then be converted to an estimated minimum total cost of compensatory mitigation funded by the project proponent.

The language of this standard REA (i.e., stepwise replacement model) includes:

- The **direct loss** of golden eagles from the take (first part of the *debit* in bird-years);
- The **lost reproduction** over two generations that is foregone because of the take (second part of the *debit* in bird-years);

¹ A *bird-year* refers to all services provided by one bird for one year. This measure of services is specific to the type of bird since different birds provide different services. So, e.g., the replacement services for 20 bird-years could be 20 birds for only one year, one bird over 20 years, or anything in between.

- The **relative productivity** of retrofitting high-risk power poles, which is the effectiveness in avoiding the loss of golden eagles by electrocution as a mitigation offset (measured in total bird-years per pole for 10 years); and
- The **mitigation owed**, which is the total debit divided by the relative productivity (*scaling*) to identify the number of high-risk power poles (*credit*) that need retrofitting to completely offset the take of golden eagles.

Using the scenario described above and life history inputs derived from the literature, Table 1 provides a summary of the results of the REA.

Table 1*
Scaling Mitigation Owed for a 5-Year Permitted Take of 5 Golden Eagles
(1 Eagle Annually)

Total Debit	28.485	PV bird-years for 5 years of GOEA take
÷ Relative Productivity of Electric Pole Retrofitting	÷0.191	Avoided loss of PV bird-years /pole
= Mitigation owed	=149.136	Poles to be retrofitted to achieve no net loss of GOEA

PV=Present Value

*More than the typical number of digits are provided to facilitate hand calculations, which may not sum to totals due to computer rounding.

Table 2 shows the same results for the mitigation owed for a 5-year permitted take of 5 GOEA (1 eagle annually) when the survival rates and reproduction are entered as zero in the REA model.

Table 2*
Revised Scaling Mitigation Owed for a 5-Year Permitted Take of 5 Golden Eagles
(1 Eagle Annually)

Total Debit	2.250	PV Bird-Years for 5 years of GOEA take
÷ Relative Productivity of Electric Pole Retrofitting	0.015	Avoided loss of PV bird-years/pole
= Mitigation owed	=149.136	Poles to be retrofitted to achieve no net loss of GOEA

PV=Present Value

*Hand calculations may not sum to totals due to computer rounding.

When a mitigation project is developed to be directly proportional to the total debit, any changes in the life history inputs in the debit are changed equally in the relative productivity of the mitigation. That is, the numerator (total debit) and the denominator (relative productivity of electric pole retrofitting) of the scaling equation move together with any changes in life history inputs. A comparison of Table 1 and Table 2 shows that the debit dropped exactly 92.1% $[(2.25-28.485)/28.485=-92.1\%]$, as did the relative productivity of mitigation $[(0.015-0.191)/0.191=-92.1\%]$. The proportional drop in the numerator and denominator of the scaling equation leads to the same credit owed.

Mathematically, the debit for the stepwise replacement model approach is calculated as:

$$(1) \quad I = \sum_{t=0} [(NB_t - N_t) \div (1+r)^t]$$

where I is the injury in lost individual-years (e.g., bird-years from a bird kill), NB_t and N_t represent the number of individuals in the population (at time t) under “baseline” and “injured” scenarios, respectively, t indexes time (usually years, but could be adjusted for months or days for short-lived and/or quick recovering species), and r is the annual discount rate (which can be adjusted for months or days depending on the units of t) (see, e.g., Sperduto *et al.* 1999, 2003; Zafonte and Hampton 2005).

From equation (1), an REA can measure I directly as the PV bird-years associated with the take (debit), which is standard for a basic stepwise replacement model. The process of scaling the mitigation project to exactly offset the debit in the golden eagle example is:

$$(2) \quad Y \text{ (credit)} = (I/\text{bird} \times \# \text{ birds taken}) \text{ (debit)} \div \text{PV bird-years/high-risk pole (relative productivity)},$$

where Y is the number of high-risk poles required to be retrofitted and I is the PV bird-years per take of *one* golden eagle.

So, based on the current inputs, equation (2) reduces to a *proportionality constant* as follows:

$$(3) \quad Y = [28.485 \text{ PV bird-years/bird} \times \# \text{ birds taken annually}] \div 0.191 \text{ avoided loss of PV bird-years/pole,} \\ = 149.136 \text{ PV poles/bird} \times \# \text{ birds taken annually}$$

That is, for this type of directly proportional avoided loss project, only the level of take (number of eagles annually), the avoided loss of eagles per mitigated electric pole, and the timing of the mitigation relative to the take affect the credit owed.

Discussion

The selected high-risk power pole mitigation for golden eagle take is an example of a directly proportional project from the perspective of a standard REA model, where the timing and development of the mitigation leads to immediate and direct offsets. That is, the numerator and denominator of the scaling are moving in proportion, and only a limited number of variables, like the level of take (number of eagles annually), the avoided loss of eagles per mitigated electric pole, and the timing of the mitigation relative to the take, affect the outcome. However, it would *not* be reasonable to conclude that the life history inputs do not matter for three main reasons:

1. **Extent of Initial Bird Losses.** The REA total debit is an important indicator to the agencies, public, and applicants/responsible parties of actual resource losses; even if it ends up that there is limited sensitivity in terms of the compensation owed. This type of project has the potential to contain the expenditure of time, effort and financial resources when there are minor disagreements over life history inputs.

2. **Extent of Cumulative Bird Losses.** A relatively accurate REA total debit is needed for the agencies, public, and applicants/responsible parties to understand the potential cumulative losses of birds over time. That is, the bird-years may be aggregated in present value to provide a clearer picture on the extent of total resource losses and potential issues for resource management.
3. **Alternative Mitigation/Restoration Options.** A relatively accurate REA total debit is needed to give the agencies, public, and applicants/responsible parties the flexibility to develop, analyze and potentially implement other types of appropriate mitigation and restoration projects. Examples of common compensatory projects that do not necessarily reduce to a proportionality constant from changes in life history inputs include bird translocation, predator removal, and land acquisition.

Additional work is needed to test the sensitivity of REA inputs for a broad range of mitigation and restoration projects.

References

- Sperduto, Hebert, Donlan, and Thompson. 1999. "Injury Quantification and Restoration Scaling for Marine Birds Killed as a Result of the North Cape Oil Spill," (US Fish & Wildlife Service and Industrial Economics, MA, March).
- Sperduto, M.B., S.P. Powers, and M. Donlan. 2003. "Scaling restoration to achieve quantitative enhancement of loon, seaduck, and other seabird populations," *Marine Ecology Progress Series*, 264: 221-232.
- Zafonte, M. and S. Hampton. 2005. "Lost Bird-Years: Quantifying Bird Injuries in Natural Resource Damage Assessments for Oil Spills," Proceedings of the 2005 International Oil Spill Conference, May 15-19, 2005, Miami, FL. [http://www.dfg.ca.gov/ospr/spill/nrda/iosc_lost_bird-years_paper_final.pdf]