



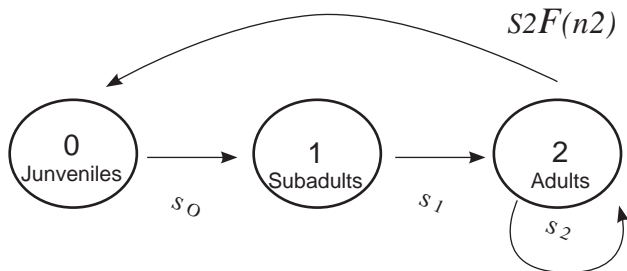
When a species of particular concern is injured by a chemical or oil spill, Resource Equivalency analysis (REA) is often used to quantify the injury and to identify a ecological restoration project that, when implemented, will compensate the public for the injury. This occurs in two steps: quantifying the magnitude of the initial injury, and projecting the impacts of the release through time.

### Technical Underpinnings:

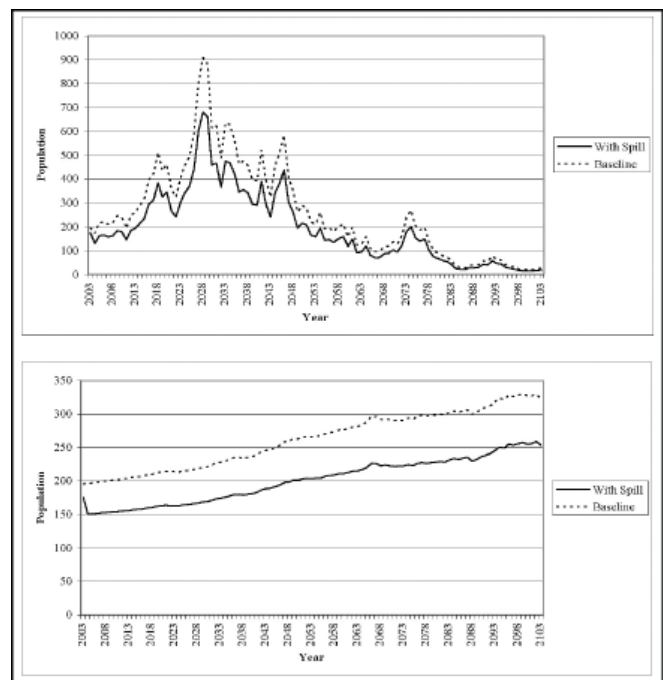
REA assesses impacts to a set of services all tied to a single population using a three step process:

1. The baseline population level is projected through time.
2. The population level given the spill and a restoration project is projected through time.
3. The size of the restoration project is adjusted until society experiences no net loss of discounted species years.

These projections are made using Population Models that rely on widely available life history data and which may have simple deterministic specifications or may be expanded to include the effects of random events or ecological constraints.



REA is often discussed in terms of “debits” and “credits”. When the “with-spill-and-restoration” population projection is below baseline, a debit accumulates. When the with-spill-and-restoration projection exceeds baseline, a credit accumulates. The public is compensated (i.e., the restoration project is “scaled”) when the present value of the debit is equal to the present value of the credit.



The metric in REA is the discounted species year. For example, if REA is being conducted for mallard ducks, one mallard living for 1 year is said to provide 1 mallard year of service. Mallard years occurring in the future are discounted to reflect society’s preference to have goods sooner rather than later all else being equal. So long as the number of discounted mallard years provided under the baseline condition is equal to the number of discounted mallard years provided with-spill-and-restoration compensation is said to have been achieved.

While these concepts appear straight forward, there are a number of complications that arise in practice. Differences in the details of implementation and approach can mean millions of dollars of National Resource Damage Assessment (NRDA) liability.

# Resource Equivalency Analysis (REA)

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Services

## Applications:

- **Carcass Based Mortality Models.** ENTRIX has developed a suite of deterministic and stochastic models to estimate initial impacts related to one-time and ongoing releases. The models, which rely on observations of injured individuals and or the collection of carcasses, account for factors such as removal by scavengers, the ability of searchers to find searches, the frequency of search, and the presence of carcasses under baseline conditions, have been used to assess impacts to birds, turtles, mammals, aquatic species, and insects at sites in MA, PA, DE, NJ, MD, LA, ID and CA.
- **REA for the Federally Listed Marbled Murrelet.** ENTRIX worked cooperatively with California Office of Spill Prevention & Response (CA OSPR) to develop a REA for the federally listed marbled murrelet. The analysis used ecological and economic principles to evaluate the effects of a one-time mortality event and identified the amount of habitat preservation necessary to make certain that the public experienced no net injury. Using the model, the NRDA team identified a restoration project approximately half the size of the project that would have been identified using the standard USFWS REA approach, ultimately saving the RP several million dollars.
- **Meta-Population Based REA for the Federally Listed Roseate Tern.** ENTRIX developed this meta-population based model to investigate the effects of low level take and spill-related colony establishment on the federally listed roseate tern. Our REA incorporated limiting factors at three island breeding sites, periodic shocks, immigration between colony sites, and the effect of differential erosion rates at the three sites. In contrast to the standard USFWS REA, the ecologically based REA demonstrates that, following the spill-related establishment of a new colony site, the public requires no additional compensation.
- **REA for the MD State Reptile, the Diamondback Terrapin.** ENTRIX worked cooperatively with Federal and Maryland state Trustees to develop a diamondback terrapin REA. The REA was used to identify the amount of nursery habitat that if restored, would make certain that the public was compensated.
- **REA for the Federally Listed Piping Plover.** ENTRIX employed a Monte Carlo based REA to evaluate the effect of a one time mortality event among piping plovers. Rather than relying on the standard USFWS REA, which suggested that a major restoration project would be required to offset a relatively short term impact, ENTRIX extended an existing USFWS plover management model such that it scaled potential restoration alternatives using assumptions and scenarios consistent with the best available science. This REA is being used in ongoing technical discussion with state and federal Trustee agencies.
- **Meta-Population Based REA for the Federally Listed Grizzly Bear.** As part of negotiations related to the take of grizzly bears, ENTRIX evaluated the validity of standard USFWS REA approaches. Our research included consideration of spatially integrated source/sink concepts, ecologically limiting factors such as food and human conditioning, and immigration related issues related to this highly territorial species. The research was used to shift negotiation away from restoration options identified by the USFWS REA and into a realm more consistent with the best management practices.
- **Tundra Swan REA-** ENTRIX developed an age-class based REA to assist in the scaling of restoration intended to compensate the public for spill-related injuries to tundra swans. The REA used Monte Carlo methods to evaluate future losses associated with continued persistence of contamination, anticipated effects of remediation, and population benefits associated with various restoration projects including breeding ground easements and waste-grain incentive programs.
- **REA Library.** ENTRIX has developed a library of REA applications that includes over 100 species of birds, mammals, reptiles, and fish. These applications all rely on REA methods developed cooperatively with CA OSPR. These “ready to go applications” have been used to evaluate impacts to common species at sites throughout the U.S.

## REA Related Publications:

- Wakefield, Tomasi, McNutt, and Stapler. In prep. Alternative Methods for Conducting REA Under Uncertainty. Targeted Journal: Marine Pollution Bulletin.
- Wakefield, Tomasi, Webber, Byrd, and Harmon. 2009. Evaluation and Comparison of Habitat and Resource Equivalency Models. A report submitted to the American Petroleum Institute. Washington D.C., 126 pp.
- Wakefield, Stapler, Tomasi, and Byrd. 2009. Assessment of Beached Bird Modeling Methods. A report submitted to the American Petroleum Institute. Washington D.C.
- Wakefield and McNutt. 2008. An Ecological Framework for Resource Equivalency Analysis (REA). Proceedings of the 2008 International Oil Spill Conference. Savannah, Georgia.
- Tomasi, Wakefield, and Byrd. 2003. Habitat Equivalency Analysis: Implications for Endangered Species. Proceedings of the 2003 International Oil Spill Conference. Vancouver, British Columbia.
- Wakefield, Tomasi, and Byrd. 2003. Predicting Spill-Induced Bird Mortality Using Beached Carcass Data. Proceedings of the 2003 International Oil Spill Conference. Vancouver, British Columbia.
- Penn and Tomasi. 2002. Calculating Resource Restoration for an Oil Discharge in Lake Barre, Louisiana. Environmental Management.