DISCOUNTING AND UNCERTAINTY IN NATURAL RESOURCE DAMAGE ASSESSMENTS

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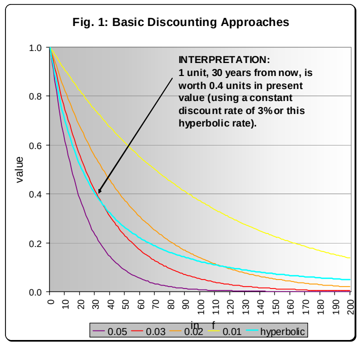
DISCOUNTING
Restoration-based scaling methods, such as Habitat or Resource Equivalency Analysis (HEA or REA), quantify lost resource services from an injury and gained resource services from a restoration project into the future. In many cases, the injury and/or the restoration project are projected to last several decades or even into perpetuity. Following economic theory and federal guidelines, resources provided (or lost) in the future are *discounted* at some specified rate.

WHY DISCOUNT AT ALL?
Discounting is done for two basic reasons:
1) Time preference: people prefer things in the present rather than in the future (e.g. a social rate of time preference).
2) Uncertainty in Outcomes
   a. Variance in project benefits: the project may do better or worse than expected; risk-averse people generally prefer a lower mean return with less variance to a higher mean return with greater variance.
   b. Risk of catastrophic failure: the project may fail due to internal (e.g. poor design or implementation) or external events (e.g. natural or political).

WHAT DIFFERENCE DOES IT MAKE?
The discounting regime or rate chosen can have a large impact on the scaling results. This is demonstrated in Figure 1. Imagine our units are *restoration credits* in terms of *acre-years* of ecological benefits. Over a 200-year period, a 1% discount rate would imply over *four times more credit* than a 5% discount rate (87.3 versus 21.0 acre-years of credit).

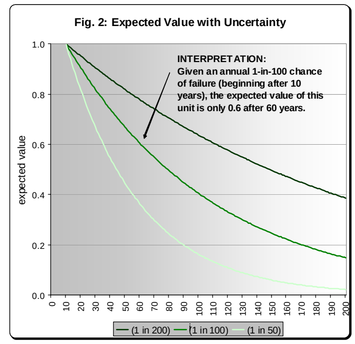
WHAT DISCOUNT RATES DO PEOPLE USUALLY USE?
Both Trustees and RPs have almost universally employed a fixed rate of 3% in NRDA cases.
- The 3% rate is recommended in the OPA 90 NRDA guidance document.
- The 3% rate is also endorsed in a DOI issue paper dealing with NRDA and is employed in the CERCLA Type A Model for NRDA, adopted by DOI.
- The 3% rate is used in the Louisiana Regional Restoration Plan.

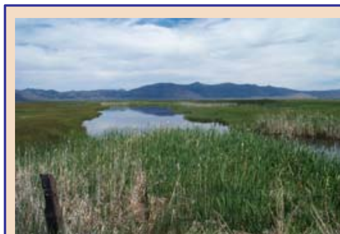
However, these rates *explicitly do not* incorporate uncertainty; the 3% is meant to reflect only the social rate of time preference.



PRESENT VALUE TOTALS

DISCOUNTING METHOD	PRESENT VALUE (PV)
Constant 5%	21.0
Constant 3%	34.2
Constant 2%	50.0
Constant 1%	87.3
Hyperbolic	42.5





A VALUABLE BUT FRAGILE CURRENCY

In NRDA settlements, the public is compensated, directly or indirectly, with restoration projects. Unlike cash, this currency is subject to considerable natural and political uncertainty over time. The following references describe shortcomings of many restoration projects:

Allen et al. 1994
Brown & Smith 1998
Cammen 1976
Craft et al. 1988
Craft et al. 1991
Craft et al. 1999
Delphey & Dinsmore 1993
Langis et al. 1991
Melvin & Webb 1998
Miller & Simenstad 1997
Peck et al. 1994
Sacco et al. 1994
Scatolini & Zedler 1996
Simenstad & Thorn 1996
Snell-Rood & Cristol 2003
Strange et al. 2002
Zedler 1993

Dead trees in the riparian zone at the Davis Wetlands restoration site. A combination of poor soil, high pH water, and insect infestation led to the demise of these trees.

IF EVERYONE USES 3%, WHY DO WE CARE ABOUT IT?
Some economists have argued that the problem with constant discounting is that the present generation values the welfare of future generations more than constant discounting implies. In order to take such concerns into account, some have suggested the use of *hyperbolic discounting*, or discount rates that *decline over time*. For example, one could employ a 3-4% discount rate for the first few years, and then allow this rate to decline over time to 1% or even close to 0% in the long run. Note that this argument addresses *time preference only*; it does *not* address uncertainty.

The blue line in Figure 1 shows how the hyperbolic discounting method gives *greater credit* to benefits far into the future.

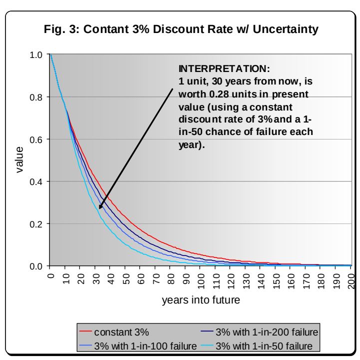
WHAT ABOUT UNCERTAINTY?
The literature on restoration projects present an overwhelming picture of underachievement, with some authors speculating that restored sites will "never reach functional equivalence" with natural comparison sites. In the OPA regulations (CFR 990.53(d)(4)), Trustees are specifically required to "evaluate the uncertainties" and to "use risk-adjusted measures… in conjunction with a riskless discount rate representing the consumer rate of time preference."

HOW CAN WE INCORPORATE UNCERTAINTY?
There are three basic ways to incorporate uncertainty in restoration project success:
1) RP-implemented projects, where the RP bears the risk of project failure (at least in the short run).

2) Lower the expected benefit level to an "Expected Value" that incorporates the "insurance" regarding the variance and the odds of catastrophic failure.

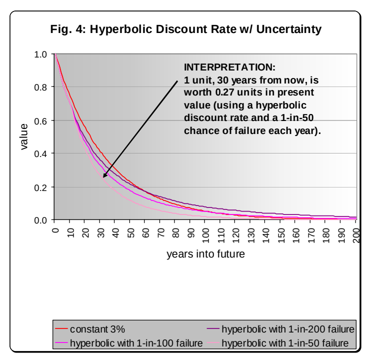
3) Incorporate risk and/or the odds of failure directly into the discount rate.

WHEN UNCERTAINTY IS INCORPORATED INTO THE DISCOUNT RATE, WHAT DIFFERENCE DOES IT MAKE?
When either the injury or restoration is long-lasting, the specification of the discount rate can have a significant effect on restoration scaling calculations. In these examples, we simply incorporate the odds of project failure into the discount rate. We conclude that uncertainty associated with restoration project benefits, if incorporated into the discount rate, can *overwhelm* the effect of time preference on the discount rate. For example, incorporating an annual 1-in-100 chance of project failure into a 3% discount rate lowers the Present Value (and amount of restoration credit) by 18% (from 34.2 to 27.9 in Figure 3). The Present Value (or restoration credit) using a hyperbolic discount rate becomes essentially the same as that using a constant 3% discount rate if one incorporates an annual risk of project failure as low as 1-in-200.



PRESENT VALUE TOTALS

DISCOUNTING METHOD	PRESENT VALUE (PV)
Constant 3%	34.2
3% w/ 1-in-200 annual failure	30.7
3% w/ 1-in-100 annual failure	27.9
3% w/ 1-in-50 annual failure	24.1



PRESENT VALUE TOTALS

DISCOUNTING METHOD	PRESENT VALUE (PV)
Constant 3%	34.2
hyperbolic w/ 1-in-200 annual failure	35.1
hyperbolic w/ 1-in-100 annual failure	30.3
hyperbolic w/ 1-in-50 annual failure	24.6

FOOTNOTES ON CALCULATIONS
For illustration purposes, the Present Value totals presented here are based on a 1 unit credit from year 0 to year 200. Most restoration trajectories incorporate a ramping up of benefits in the first 10 to 20 years. In such a case, any differences between discounting regimes in those early years would be diminished.

The hyperbolic function used here is derived from Weitzman, M.L. 2001. Gamma Discounting. *The American Economic Review* 91: 260-271. Specifically, we use his recommended parameters of μ = 4% per annum and σ = 3% per annum.